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THE CURRICULUM AND AIMS IN BIOLOGICAL TEACHING.

BY THOMAS W. TURNER,

Hampton Institute, Hampton, Va.

As we examine the curriculum and the results of biological teaching in our schools and colleges we find numerous and strong reasons for urging a complete recasting and reorganization of this important division of our school program. An experience of twenty-five years' teaching and of observing progress in Biological Sciences confirms the writer's growing opinion that the schools are playing a rather backward role in preparing the youth of the country to cope with the innumerable problems, mostly biological, with which they and the whole populace are brought into daily contact.

Some of these problems have already become more or less acute and have furnished occasion for the broadcasting through various publications of startling prophecies of impending national and international disaster. The prophecies frequently have little to support them. They are sometimes sheer propaganda, but they are always significant. In the last few years, the reading public has been deluged with flaming titles and their no less inflammatory contents, such as "Yellow Peril," "The Rising Tide of Color," "Mankind at the Crossroads," "White America," and many others. Some of the scare headings are, it is true, the works of men engaged in the biological field, but the majority of them emanate from writers who have not had even a smattering of biological training in any formal manner. It is difficult in the present generation to convince a student who expects to follow Journalism and Book-making as a career that his catalog of studies should include a certain minimum of biological courses; such a task was well nigh hopeless a generation ago,

so the writer of today who was the student of a former generation deals with biological problems largely from the standpoint of feeling and conjecture rather than from that of investigation and fact. Unfortunately, the public mind is made up mainly from the output of writers of this type, and the growing spirit of narrow mindedness, racial hatreds, and so-called controversies between Science and Theology may be traced unerringly to a mistaken school program which either omitted certain fundamental subjects entirely or made little attempt to treat them as vital factors intimately connected with the development of the race: for instance, History, as a subject of the curriculum far antedates Biology. This subject deals with the vital events of human life. The application of biological principles to man, though admitted for plants and lower animals, still gives a shock to many minds, yet a conception of History as a struggle for existence among human beings with its attending natural selection and survival of the fittest, giving due consideration to the part which intelligence has played, would remove this subject from an ancient classic setting—a setting which portrays man as having no correlation, nor biological counterparts with other organisms—and would place it upon a background which has both the pedagogic appeal and the dynamic force to serve as a permanent stimulus in the acquisition of information about the life history of the race as a whole, as well as that of the different branches of the human race. Such treatment would give a vital and rational foundation for the securing and the holding of the pupils' interest. Mr. Wells' "Outlines of the History of the World," is probably the best and only serious attempt yet published which aims to interpret the past of man from this vital standpoint.

The formulas and laws of Physics, Chemistry, and Mathematics are nothing more than the products of man's struggle on the mental side to reduce to a workable basis the innumerable and apparently unrelated physical phenomena which confront him daily and which he has succeeded in converting to his own use in order to survive. On the anatomical side, man's growth reached its equilibrium ages ago, but the reaches of mental achievement give every evidence of being limitless. It would seem fitting then that more attention should be given in the biological laboratory to the struggle for existence on the mental side and the varied forms which these struggles have taken.

What is said above may be applied equally to Physical Education and many other subjects of the curriculum, particularly those that were there before Biology, as such, was a recognized essential. In each case, the organization of matter and the point of view could, with great pedagogical gain, be revised and redirected in the light of the changed attitude which has come over us as to life and the living processes following the publication of Darwin's great work in 1859.

But, this wished for reorganization is not proceeding with any great assurance at the present time. Nor can we look forward to the near future with any bright hopes that biological teaching is to be allowed to function through the schools much beyond the material needs of food and clothing.

The need of emphasizing this phase in a biological course cannot be denied, but it must be recognized as only one element which urged man on directly or indirectly, as he achieved success after success in overcoming the forces of nature. In other words, to teach Biology simply as a function of animality stressing only the baser needs of the animal is not doing full justice to youth. For when one contemplates the entire sweep of human development and gets a realization of all forces which have played a part in this development, it becomes evident that the purely animal wants play a less and less important role while the higher spiritual quests become more and more important.

Biological teaching has not yet reached the stage, mainly from lack of trained teachers, where it can appropriate this developmental fact as a definite part of the laboratory procedure. This teaching is just beginning to appreciate that the education of man as a living being must make ample provision not only for giving information about his structure and physiological processes, but must recognize that as structure developed, the intellectual, the social, the economic, the aesthetic, and the religious development went hand in hand. It should become evident, therefore, that a course in Human Biology that does not seek to integrate these different elements of man's life is making an appeal which is entirely too narrow, and is leaving a large part of its legitimate field as a bone of contention for professional controversialists and emotional fanatics.

In the suggestion that the biological curriculum give direct attention to these phases of human progress which it has heretofore ignored, I do not mean to imply that limitations should

be placed upon the development of special phases, as such, any more than covering the elements of Arithmetic, Algebra, and Geometry in a general course in Mathematics, would limit the expansion of any one of these branches as a special field.

In examining the tables of contents of a large number of textbooks in elementary Biology, Botany, and Zoology, we find, following the usual matter dealing with structure and function, rather extensive treatises upon such topics as "Heredity and Variation," "Evolution," "Genetics," "Plant and Animal Breeding," "Ecology or the Relation of Organisms to Environment," "The Social Relations of Plants and Animals," "The Origin of Species," "The Rise of Intelligence Among Animals," "Parasites," and so on, but in our elementary textbooks dealing with the Biology of man or Human Physiology, though the lower organic phases are treated, all reference to these fundamentally important principles are studiously omitted. Those of us who have spent many years teaching the subject are hardly at a loss for explanation, but the day is here when the welfare of the individual and of the nation demands that the schools should throw off their cloak of hypocrisy and prejudice and teach the plain facts.

The systematic and genetic relationship of plants is carefully studied and drilled into youth in the schools and colleges. The same is true in a larger sense with animals, but when we come to man, the statements which we find often border on the ludicrous and fail completely to do justice to the intelligence of even a grammar school child when offered as biological information. The following is a paragraph from a well known textbook of Biology which aims, in brief, to set forth a classification of man:

> "*The Races of Man*—At the present time there exist upon the earth five races or varieties of man, each very different from the other in instincts, social customs, and, to an extent, in structure. These are the Ethiopian or negro type, originating in Africa; the Malay or brown race, from the islands of the Pacific; the American Indian; the Mongolian or yellow race, including the natives of China, Japan, and the Eskimos; and, finally, the highest type of all, the Caucasians, represented by the civilized white inhabitants of Europe and America."—*Essentials of Biology*, G. W. Hunter, p. 320, 1911.

This is a fair sample of the material to which our youth are exposed. One sees at a glance that while biologists in other fields are spending their lives in trying to find relationships and compatibilities among the various groups of living things, when he comes to deal with his own species he is content to

emphasize and present to his youth only the differences, the incompatibilities, and the contrasts. This leads to the query as to how we can reorganize our courses in Human Biology so as to change this attitude and to make them function more effectively in emphasizing the similarities and the harmonies, in order to preserve the life and to promote the solidarity of the human race.

Looking toward that happy result, I would suggest the following topical outline:

1. An introduction setting forth in detail and with ample illustrations, the phylogenetic tree of the human species; emphasizing particularly the material conditions under which similarities and differences have occurred in the course of ages.
2. A general survey of the characteristics which are common to all animals, functional and structural (man included, of course).
3. A general survey of the characteristics which distinguish man:
   (a) The Neurological basis, growth and function of intelligence.
   (b) The Aesthetic Sense: its origin, function, and structural basis
   (c) Emotions: origin, anatomical basis, function; those which make for survival; those which do not.
   (d) Religion: traced from primitive man through such manifestations of it as are observed in so-called civilized communities. The teacher of Human Physiology who is seeking to enlighten the child as to the factors which have played their part in the development of the individual and the race cannot avoid giving some attention to a discussion of Religion and the part it has played in this development. The central idea to be emphasized in treating this topic as well as others is the survival value in each case. Creeds and dogmas, of course, would find no place here.
4. The conditions which make for impairment of the nervous system and the consequences of such impairment: (Here, questions of disease, overwork, loss of sleep, worry, lack of oxygen, the effect of narcotics, malnutrition and other conditions may be discussed.)
5. Developmental Period of Man:
   (a) The period before birth and the influences affecting the individual during this period.
   (b) The period from birth to maturity: special emphasis being placed on the physiology of the growing child and of the youth, the structural and psychic changes occurring during this period.
6. The Special Physiological Systems which Characterize Man in Common with other Vertebrates:
   (a) Supporting System.
   (b) Motor System.
   (c) Conductive System.
   (d) Receptor System.
   (e) Digestive System.
   (f) Circulatory System.
   (g) Respiratory System.
   (h) Excretory System.
   (i) Reproductive System.
   (j) Endocrine System.
7. Health and Disease. "Race Poisons."
8. Race Improvement:
   (a) Through Environment.
   (b) Through Education.
   (c) Through Eugenical Measures.
9. Adaptability and the Search for Food. (Here emphasize migratory movements: emigration, and colonization.)

10. Struggle for Human Ideals:
    (a) Through physical force alone: war
    (b) Through arbitration and cooperative interracial efforts: peace

Adequate laboratory work to go with such an outline might be easily planned. If the basic work in the general physiology and anatomy of animals has been adequately done, it need not be repeated here, but a somewhat detailed study of human behavior might be taken up as suggested by Watson, (Behaviorism) and much other scattered material now mislabeled and offered under the heading of Physiological Psychology would find its logical place in such a course. Such an outline is admittedly suggestive only, but the Biology teacher who is deeply interested in having this subject function in the superior development of man as a super-animal would welcome a course in the Human Body which would put less and less emphasis upon the purely animal functions and structures and more upon those traits which distinguish man and set him off from the lower animal world.

It will be noted that in the foregoing I have raised the question as to whether the time is not ripe for the biological portions of our school and college curricula to appropriate more of the factors of human progress as belonging to its own particular field rather than suffer these vital factors of life and struggle to risk the failure to interest which will surely be their fate if the older classic bases of interpretation are adhered to. I have proposed, further, a brief outline of contents for a course in Human Physiology or Human Biology which aims to set before the young the humanness of life, leaving the characteristics of animality to be solved in prerequisite school exercises.

I have purposely given consideration first to the course in Human Biology which should be the *last* to be pursued in a scheme of biological sequences, for the reason that teaching in this field has from the grammar school to the college been weakest and least meaningful.

An introductory course in biological sciences should be required for all college students, equal consideration being given to the plant, animal, and human phases both as to time and content.

I shall not attempt here to outline a choice of topics for courses in Plant and Animal Sciences since numerous manuals can be had which give these in more or less detail. It would, perhaps, be more fitting should I sound a note of warning con-

cerning the point of view and the aims which should be constantly kept in mind if the subject is to fulfill its part in the education of the student.

A course in General Zoology that remained oblivious to the ravages of insects which were bringing about the defoliation and destruction of shade trees just outside of the laboratory window should have its value for education seriously questioned. The same challenge is due courses in Botany, the limit of whose application, as far as the student is concerned, is the four walls of the laboratory. The products of such narrow training are a too frequent output of the present day laboratories and the explanation lies mainly in the fact that the instructor has either no crystallized aim which is guiding his teaching, or he is giving his course under the domination of the professional schools. The pre-medical, pre-dental, and other ultra-academic institutions have about disrupted entirely the true aims and the morale of our biological courses, particularly in the smaller colleges and high schools. We have striven with much exertion to impress the requirements which they have set, and we have done little else. The result is that the great social problems—the problem of health and better community life, the problem of food and agriculture, of racial adjustments and race improvements, and the problem of cooperative endeavor on the basis of peace and harmony have never been held up before the student as the legitimate ends of his Biology course, but have been treated as subsidiary or secondary in value.

The far reaching significance of normal, healthy men and women in a community cannot be overestimated. Whether the evaluation be on the low economic plane or whether it be based upon higher considerations, which recognize, fundamentally that the most enduring way to save men from their sins is to make sure first that they are saved from their bodily ailments.

On the economic side we are told that the average American loses seven days a year through sickness, and over a third of the deaths each year can be prevented.* This loss translated into dollars and cents is simply staggering. When we realize further, that such losses are usually the unfortunate happenings to the poorer masses who are at the same time in greatest want, we can see the need of presenting the subject of health

*Sci. News Letter—*10*:53, 1926.

on a more pedagogical basis than has been the case in the past.

Again, the extent to which a physical structure debilitated by disease, that has brought about weakened moral resistance, is responsible for the roster of our prison cells cannot be precisely determined at this time, but we have varied accumulations of undigested statistics, dealing with these unfortunates which point quite conclusively to their criminal careers as an outcome of subnormal health. Certain facts reported by C. C. Jensen ("Our Convict Slaves"—Atlantic Monthly, Vol. *137*: 599, 1926) speak very eloquently in this connection. He reports that an examination of 3,800 men and women prisoners in a large prison camp in one of our southern states showed 891 to be suffering from syphilis, 122 from tuberculosis, 421 from diseases and severe defects of the eyes, 112 from disease enough to cause blindness unless properly treated, 365 from gastrointestinal diseases, 10 from intestinal ulcer, 28 from appendicitis, 1,477 from diseases of the nose and throat, 2,847 from diseases and defects of the mouth, teeth, and gums; further, the report states not only that these are not all of the figures, but makes it clear that there are no grounds for assuming that these diseases were contracted in the camp. If we now add to these figures the results of examinations of millions of the very flower of American youth made a few years ago in preparation for the army draft in which fully a third were found to possess physical defects which seriously handicapped them for any sustained endeavor, certainly deep concern should be felt by the prison reformer as well as by the educator as to the place where the emphasis should be centered.

The forces in Biology must be concerned with the production and conservation of the national food supply. The increase in our urban population with the consequent decline in the rural will bring this question more and more to the front, and will necessitate more accurate knowledge of plants and soils than we now have.

This is not a question which concerns teaching in the rural environment solely, but it concerns the city high school and the city college in equal measure. These institutions must do their share in setting forth the dependence of the whole population upon the products of agriculture. The duty of creating an atmosphere so all-pervading that youth and age alike will regard country dwelling, as a mode of living, not secondary nor subordinate to dwelling in the city is one common to all the

schools of the land. No "back-to-the-country" movements are likely to succeed until our great centers of population through the schools shall join with the more sparsely settled rural centers in the task of creating sane attitudes toward rural conditions and rural living.

Finally, we come to problems of racial adjustments and cooperative endeavor. The question may be asked: what has the biological laboratory to do with these since it has been repeated many times, as the ruling convictions of scientific men, that there is no problem of race, biologically speaking, among human beings? Yet, the turmoil, the strife, the intolerance, and the bigotry which we see around us would indicate that there are still troublesome obstructions to be removed before men will see each other in the proper light. The laboratory can do much toward removing these obstructions, by presenting impartially the achievements of each group in so far as these achievements are recognized as biological factors; for every race which has survived and made progress undoubtedly possesses many characteristics worthy of note. To the tremendous progress made in modern times we must pay due deference. We must give credit further to the intellectual acumen of the distinct and separate racial groups which have contributed to this progress. This has been an age characterized primarily by the ascendancy of the paler peoples, and each group has made its contributions in no small measure; but these peoples are the "heirs of all the ages." It is inconceivable that any should claim that its accomplishment was unrelated to that which has gone before. They have delved into the past of Egypt, Babylonia, Chaldea, Assyria, Greece, and Rome; they have linked themselves to the heritage which was truly theirs, and have, through industry, woven a fabric of their own design which has come to be called modern civilization. As in a piece of cloth, we cannot distinguish the individual threads which compose it, so we are not all competent to recognize directly the composite character of the present civilization, but this one fact is true, that whatever this age or the dominant people of the present have accomplished rests surely and firmly on the foundation of all that has gone before. The dominance of man and races is short-lived. The proud, haughty, domineering people of today may be the cringing, begging, sycophantic paupers of tomorrow. Within the brief span of man's authentic history, we have record of the rise to power and the decadence of various human tribes—black, yellow,

and white; we do not know and probably cannot know what characteristics or lines of conduct have the greatest survival value and are most enduring, but it should be the chief aim of courses in Human Biology to seek out and stress every factor which makes for peaceful, harmonious, cooperation among races and among nations.

MOTIONS OF ELECTRONS.

By Arthur A. Blanchard,
Massachusetts Institute of Technology.

Out of the chaos of deductions from arbitrary postulates about the motions of electrons emerge a few general conclusions which are certainly valid and are of the utmost use to chemists in *classifying* but *not in explaining* chemical phenomena.

First: Electrons can occupy only a certain number of distinct levels of energy—also of distance—in an atom.

Second: The number possible at a level increases in going outward from the nucleus, the maximum numbers being 2, 8, 18, 32, ———, or twice the squares of the successive whole numbers.

Third: The stability of a group at a given level varies with the level, with the nuclear charge, and with the number in the group. In general the group of eight is the most stable in an outer level, but the inner levels may fill up, when the maximum number allows it, to groups of 18 or 32 which become very stable.

Fourth: An outer incomplete group is unstable; it may acquire more electrons to make up the group of eight, or lose all of its electrons if the number be few.

Fifth: The stable groups of eight may be completed by a small number of electrons occupying at the same time positions in the outer layers of two atoms.

Sixth: Subject to the requirements of the definite levels, the electrons arrange themselves in atoms and molecules in the positions that best satisfy the ordinary forces of electrostatic repulsion and attraction.

The nucleus presents us with examples of utmost simplicity on the one hand, and of most awful complexity on the other hand. The simple facts are that the nuclei of all the atoms are charged with an even number of unit charges, the unit being the charge of the hydrogen nucleus. The mass of every nucleus is an exact multiple of a mass equal to one-sixteenth the mass of the oxygen nucleus. Elements with fractional atomic weights are mixtures of atoms with identical chemical properties but with masses which are integral multiples of the unit. It is believed that every nucleus is built of protons, or hydrogen nuclei, and electrons with the former in greater number, so that the net charge is positive.

Complexities appear when we consider how the aggregate of protons and electrons is held together in a space hardly greater than the space occupied by a single electron. The uranium nucleus contains 238 protons and 146 electrons. The enormous amounts of energy given off in radioactive changes, which involve decomposition of the nuclei, give an indication of what amounts of energy are held bound in the nuclei.—Extracts from an address before the New England Association of Chemistry Teachers.

A SYSTEMATIC PROCEDURE IN THE DEVELOPMENT OF A LEARNING UNIT IN MATHEMATICS.

By Charles A. Stone,

University High School, University of Chicago.

Recently two objections have been raised against present standardized tests, i.e., (1) they are measures of static efficiency in learning rather than of growth in efficiency and (2) they cannot be adapted to instructional purposes. Thus they do not provide for one of the chief outcomes of the measurement movement in education, namely, to supply both teachers and pupils with objective standards by which they can estimate progress made in the study of school subjects. The writer believes that the above objections have led to the adoption of improved class examinations as devices for measuring growth in the classroom, and as instruments for diagnosis. As one studies the mass of tests evolved as a result of the testing movement he cannot help but feel that the majority of them measure performance on the part of the pupil without taking into consideration the real product of learning. What is usually obtained is a score or a rank by which pupils, classes, or schools may be compared with regard to one phase of classwork. Hardly ever can one determine from the results obtained just how pupils progress in learning, the unit for which the assimilative material stands, whether the learning is permanent, or whether the acquired knowledge can be applied to new or practical situations.

Now it cannot be overemphasized that the individual pupil rather than the class is the unit of instruction. It is frequently economical for the teacher to teach in terms of the group as a whole, but such group teaching can not prove successful unless marked individual differences are discovered and provided for. The more the teacher knows about the abilities and knowledge of the pupils of his class the better able will he be to adapt the materials and instruction to the needs of his pupils. It is a mistake to think that useful facts concerning the individual pupil can be best obtained by the use of standardized tests and a complicated technique of measurement. One cannot deny that standard tests or scales provide common tasks of known degrees of difficulty, provide standard scores, and make possible a more accurate comparison of different groups of children. Yet from the standpoint of the view of the classroom teacher they lack precision, as they do not measure the specific results of instruc-

tion, they do not measure progress or growth, they do not determine the adaptability of the subject matter to the pupil, nor do they point out pupil difficulties as they occur in the classroom.

Thus the object of this paper is the presentation of a technique designed to keep the teacher informed as to the progress of every individual toward mastery in a given unit of mathematics. The above technique will endeavor to make a preliminary appraisal of the present experiential background of the pupil with respect to the unit itself, determine how much teaching is needed in individual cases, determine whether or not teaching has registered, and finally determine pupil difficulties and their remedies.

The class selected to demonstrate the procedure was a freshman class at the University High School taught by the writer. This class was chosen because it was about to take up a new unit of work at the time that experimentation was to be started. The unit to be studied was entitled "Angle Pairs" and the assimilative material studied by the class is found in Breslich's, First Year Mathematics for Secondary Schools. A careful examination was made of assimilative material in order to determine the elements to be included in the test. A test was then constructed which in the opinion of the writer would give the following information:

(1) Adaptability of the material to the needs of the pupils.

(2) The pupil's ability to understand the printed page.

(3) The pupil's ability to select from material studied and to apply it to problems.

(4) The pupil's ability to adapt and apply material to new but similar situations.

The test follows:

TEST—UNIT 5—ANGLE PAIRS.

Part I.

Complete the following sentences:

1. The sum of the acute angles of a right triangle equals.....
2. A triangle having two equal angles is.....triangle.
3. The side opposite the right angle in a right triangle is called the .....
4. The sum of the adjacent angles about a point on one side of a straight line is.....degrees.
5. The sum of all the angles at a point just covering the angular space about the point is.....degrees.
6. In the following statements put a check mark for those that are correct and a cross for those incorrect: (see Fig. 1.)

..... a and b are adjacent angles.
..... b and c are supplementary angles.
..... b and e are opposite angles.
..... b and e are complementary angles.

..... c and d are adjacent angles.
..... a and c are adjacent angles.
..... b and c are adjacent angles.

7. Draw an angle adjacent to the angle X. (Fig. 2.)
8. Draw an angle that will be the complement of angle r. (Fig. 3.)
9. Draw an angle that will be the supplement of angle Z. (Fig. 4.)

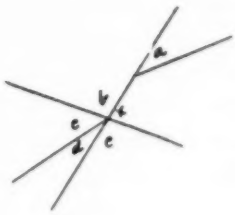

Fig. 1

Fig. 2

Fig. 3

Fig. 4

10. Put check marks in the figures below that contain perpendicular lines. (Fig. 5.)

Fig. 5

11. Draw a figure to represent an isosceles triangle.
12. How many right angles may a triangle have?.....
13. To what is the sum of the angles of a triangle equal?.....
14. How many perpendiculars can be drawn to a given line at a given point?.....
15. What is the complement of an angle of 60°?.....
16. Two angles of a triangle are 60° and 100°. What is the value of the third angle?.....
17. If the marked angle is 70° (Fig. 6), find the angle X.....
18. If the marked angle is 50° (Fig. 7), find the value of S.....
19. In Fig. 8, mark with the letter C a angle which forms with A, a pair of alternate interior angles.
20. In Fig. 8, mark with the letter D, an angle which makes with A, a pair of corresponding angles.
21. One acute angle of a right triangle is 72°. What is the other acute angle?.....

Fig. 6

Fig. 7

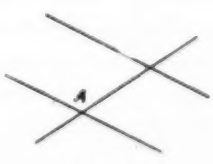

Fig. 8

Fig. 9

Part II.

22. An angle at the vertex of an isosceles traingle is 80°. Find each of the other angles.....

23. If angle A is twice as great as angle B, find the size of angle C. (Fig. 9.)

24. X° is the supplement of X°+84°. Find the angles.....

25. In the figure at the right find X and the other angles. (Fig. 10.)

26. In Fig. 11, at the right if c=e, prove a=g.

27. If c+f=180°, prove f=d. (Fig. 11.)

28. In the adjoined figure find X and the two angles. (Fig. 12.)

29. Using (Fig. 13), at the right write the equation that would give a value for X. Do not solve.

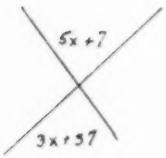

Fig. 10

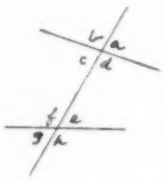

Fig. 11

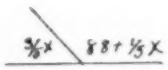

Fig. 12

Fig. 13

In order to determine the experiential background of the pupils with respect to the unit it was decided to administer the test to the class before a study of the unit was attempted. The value of this procedure is pointed out by Prof. H. C. Morrison[1] who maintains that it can be conceived as having three principal purposes: economy, the establishment of apperceptive sequence, and orientation.

Many readers perhaps can report cases of pupils repeating the work of a course one or more times. How can interest be aroused in pupils compelled to pursue a subject for the second and third time in a class which is for the first time coming into contact with material of the unit and has but a vague conception of its meaning. Now in every class the teacher will find one or more pupils who have come in contact with some of the contents of the unit either through practical experience or through previous learning which may have touched upon the substance of the unit. Then again there may be found pupils who forge ahead of the class. The pretest will most likely reveal these cases and will indicate an economical program to the progressive teacher. Thus the pupils who have shown a previous knowledge of the unit but who have not shown intellectual independence can be put to work on new material related to the subject for the purpose of

[1]Henry C. Morrison. The Practice of Teaching in the Secondary School. The University of Chicago Press, Chicago, 1926.

increasing their powers. The pupil who works in advance of the class and has shown evidence of intellectual independence might be excused from the routine of the class to undertake the study of a related project to increase intellectual growth.

The preliminary test also serves to orient the teacher with respect to the presentation of the new unit itself and its subsequent teaching. It gives the teacher the correct point of view from which the new unit should be attacked with this particular class or group, and aids in determining the individual needs of the pupils in the given unit.

Table I shows the responses of the pupils to the test before they have had the opportunity to study the assimilative material of the unit. The table reveals a number of interesting facts. It seems that questions 12, 13 and 16 referring to the interior angles of a triangle might just as well have been omitted. The principle concerning the sum of the interior angles of a triangle had been taught in a previous unit, and was included for review purposes since it is used in developing some of the relations between angle pairs in a triangle. Since the results show that the pupils have mastered this principle any reference to it may be omitted from the unit being considered.

It is further seen that no pupil responded incorrectly to every question, showing that all had some previous knowledge of parts of the unit. Indeed the knowledge of the unit shown by some pupils is surprising. Pupils M and Q gave correct responses to twenty-eight of the thirty-five parts of the test. The effect on these pupils would be deadening if they were required to work through all of the assimilative material. They were called in for a conference and it was revealed that they were familiar with some of the subject matter of the unit having studied the topic of mensuration in the grammar school. These pupils had been doing excellent work in previous units and showed that they were capable. Their I. Q.'s were respectively 123 and 116. They were assigned some work that would clear up points in the unit that they did not understand. After completing this work they were excused from the class routine and were permitted to work on projects related to mathematics, and were given to understand that they would be called in at anytime for a mastery test on the unit.

Pupils B, C, D, K, L, N, and R showed a good knowledge of the unit having given from twenty-one to twenty-three correct

TABLE I—PUPIL'S RESPONSES BEFORE ASSIMILATION COMMENCED

Question	1	2	3	4	5	6 a	6 b	6 c	6 d	6 e	6 f	6 g	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total Rights
Pupil																																				
A		x			x		x		x	x		x		x	x	x				x	x		x	x		x		x	x		x	x	x			16
B		x	x						x					x	x	x							x			x	x	x		x	x	x	x			21
C	x	x												x	x		x				x				x	x			x		x	x	x			23
D	x						x							x	x						x			x	x	x		x	x		x	x				23
E	x	x	x	x	x		x		x					x	x	x	x		x		x		x	x			x	x	x	x	x	x				13
F	x	x	x	x		x	x		x	x	x	x	x				x	x			x		x	x	x	x			x	x		x	x	x	x	11
G	x	x		x		x	x			x	x			x	x						x		x	x	x	x			x	x	x	x	x		x	18
H	x	x	x	x	x				x	x	x	x	x	x	x		x				x			x	x	x	x	x	x	x	x	x	x	x		10
I					x				x	x		x	x	x	x	x					x		x	x	x			x	x	x	x	x	x	x	x	15
J	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x				x			x	x	x	x	x	x	x	x	x	x			8
K		x	x				x		x			x		x			x				x				x			x		x	x	x	x			21
L	x	x	x				x							x	x						x				x		x		x	x	x	x	x			21
M	x								x					x						x	x					x						x				28
N		x	x				x							x	x					x	x				x	x		x		x				x		22
O	x	x	x			x	x	x	x		x			x	x	x	x				x			x	x	x	x	x	x	x	x	x	x			11
P		x	x		x				x					x	x	x				x	x			x	x	x	x	x	x	x	x	x	x	x	x	15
Q					x		x		x					x							x			x	x							x				28
R		x	x				x		x					x	x						x							x			x	x	x			23
Totals	**8**	**4**	**7**	**13**	**11**	**14**	**6**	**16**	**6**	**12**	**13**	**12**	**14**	**1**	**4**	**12**	**11**	**17**	**17**	**14**	**2**	**18**	**13**	**10**	**5**	**6**	**11**	**7**	**6**	**4**	**6**	**2**	**1**	**11**	**13**	**327**

responses. The above pupils had also studied mensuration in the grammar schools and hence were also familiar with some of the subject matter in the unit. Their I. Q.'s are respectively 106, 135, 97, 119, 101, 117 and 112. Pupil D has a comparatively low I. Q. and does not work as rapidly as the others, but he is persistent and exerts a tremendous effort to do the work. Pupils A, E, L, J and O made surprisingly low scores in view of the fact that they had been doing excellent work in the past year and seemed to be very alert at all times. Their I. Q.'s are respectively 121, 123, 108, 104 and 115. A conference with the above pupils brought out the facts that pupils A, E, I, and J completed the eight grades of the grammar school. When questioned concerning previous instruction with reference to the particular unit they replied that they thought they had something like it but could not definitely remember. Pupil O completed seven grades of the grammar school and had not had the work of the eighth grade. Thus, her score is not surprising. Pupil J made the lowest score of the group. She was certain that she had not seen any material that had any connection with the unit. Pupils H and B likewise lacked the preparation of the eighth grade, and their scores indicated that they would need special attention during the assimilation of the subject matter. Pupil G with an I. Q. of 116 had been through some of the material in the elementary school and should have scored higher. A study of the work of this pupil revealed, however, that, while he was capable, he would work well only under pressure. It was evident that he would need careful watching. Pupil F had studied some geometry in the grammar school and gave eleven correct responses. He did well in view of the fact that his I. Q. is 86, and that he is a slow learner. His past work had shown that, while he was very slow in assimilating subject matter, he retained it once he grasped it. Apparently this pupil would need very careful attention.

After two weeks of assimilation the test was given again to see what improvement, if any, the pupils had made due to contact with the unit. The results are given in table II. It might be mentioned at this point, that at no time were pupils permitted to see their papers. Likewise, the test questions were seen by pupils only at the time of taking the test. An examination of table II reveals the fact that learning is progressing rapidly with but few exceptions. Pupil F still shows evidence of slow learning.

TABLE II—PUPIL RESPONSES AFTER TWO WEEKS OF ASSIMILATION.

Question	1	2	3	4	5	6 a	6 b	6 c	6 d	6 e	6 f	6 g	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total Rights
Pupil																																				
A																										x						x	x			32
B		x				x									x			x					x		x	x						x	x			21
C		x																																		31
D	x													x							x			x						x	x	x				26
E		x	x						x																			x	x	x	x	x				26
F			x				x		x			x		x	x			x					x	x	x	x	x		x	x		x	x			27
G							x																													17
H			x											x							x			x					x		x		x			29
I						x			x					x							x				x					x	x	x				28
J			x											x							x						x				x	x	x			26
K																								x		x		x	x		x	x				26
L			x				x			x							x									x				x		x				32
M																											x		x	x	x	x	x			25
N																					x									x		x				32
O						x	x							x												x						x	x	x			31
P			x			x								x	x				x		x		x			x			x	x	x						26
Q														x	x				x		x	x				x	x	x	x	x	x	x				20
R																									x	x						x				32
			x											x							x											x				31
Totals	**17**	**15**	**11**	**18**	**18**	**14**	**14**	**18**	**15**	**17**	**18**	**17**	**18**	**10**	**15**	**18**	**17**	**16**	**17**	**18**	**10**	**17**	**15**	**14**	**14**	**9**	**15**	**14**	**9**	**11**	**5**	**3**	**5**	**16**	**14**	**492**

Consultation revealed the fact that he was having difficulty in interpreting the printed page and was unable to see relationships in mathematical expressions. This pupil was given special attention. Pupil B showed no improvement on Test 2. She responded correctly to five questions previously missed, but on the other hand she missed five that she had previously checked correctly. Apparently this pupil had been doing some guessing on the first test. When the opportunity presented itself she was shown that she was guessing instead of thinking. Pupil P showed some improvement but made the lowest score on the test. This was due to the fact that frequent absence was interferring with her work. The remedy here is apparent.

It is interesting to note that problems 25, 26 and 27 stand out for their difficulty. Unless a careful study is made of the situation one would be led to think that these problems are mis-fires and hence do not belong to the unit. This is not true however. In reality the problems are applications of some of the principles taught in the unit, and the results show conclusively that the majority of pupils cannot apply them in new situations. This point demonstrates clearly the value of unified mathematics. It is not enough to teach pupils that the opposite angles are equal when two straight lines intersect, but they should be given many applications of this theorem to insure its mastery. The assimilative material of the unit in question provides many applications, and it was felt that after the pupils had come in contact with them that they would respond correctly to questions 25, 26 and 27.

Ten days after the second test the unit was completed, and it was decided to give the test as a mastery test. The responses appear in Table III. The results indicate that we have good evidence that pupils A, C, H, J, M, N, Q and R have mastery. In the cases G, I, K, L, O and P we cannot be at all sure of their mastery without further individual study of their reactions. As for the rest of the pupils we have definite evidence that mastery has not taken place and hence know that reteaching is necessary. The showing as a whole, however, is creditable

The writer cannot help but feel that the satisfactory showing made on the final test is due to the fact that testing has been considered a part of the teaching process. Instead of being concerned with the test scores the teacher is interested in the analysis of the results, thus throwing light upon the pupil and

TABLE III—PUPIL RESPONSES AFTER COMPLETION OF THE UNIT

Question	1	2	3	4	5	6 a	6 b	6 c	6 d	6 e	6 f	6 g	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total Rights
Pupil																																				
A																																				35
B						x	x											x					x	x								x			29
C																																				35
D	x					x																							x	x			x			30
E														x												x		x				x				31
F								x	x	x	x																	x				x	x			28
G						x	x																													33
H																																				35
I																												x					x			33
J																																				35
K																								x		x							x			32
L																														x			x			33
M																																				35
N																																				35
O																										x										34
P			x																														x			33
Q																																				35
R																																				35
Totals	**17**	**18**	**17**	**18**	**18**	**15**	**16**	**17**	**17**	**17**	**17**	**18**	**18**	**17**	**18**	**18**	**18**	**17**	**18**	**18**	**18**	**18**	**17**	**16**	**18**	**15**	**18**	**15**	**17**	**16**	**18**	**16**	**11**	**18**	**18**	**596**

his needs. Effective testing is as fully important as effective teaching.

SUMMARY.

The above technique is valuable to the teacher since it makes for economy in learning by giving the following information:

1. Experiential background of the pupil with respect to the unit.

2. The amount of teaching needed in individual cases.

3. The progress of the pupil in learning.

4. Adaptability of the subject matter to the needs of the pupil.

5. The pupil's ability to select from material studied and to apply it to problems.

6. The pupil's ability to adapt and apply material to new situations.

7. Pupil difficulties and their remedies.

SEX EXTRACT OF FLOWERS.

The much-quoted aphorism of Kipling, that "the Colonel's lady and Judy O'Grady are sisters under their skin," is capable of a much wider extension, to include all living female beings, both animal and plant, if results reported by Prof. Bernhard Zondek, of the University of Berlin, may be taken as a criterion. For he has shown that female animals, rendered sexually inactive by surgical operations, have their missing instincts restored to them by extracts taken from the female organs of plants. His most powerful vegetable "love potion" was extracted from the pistillate catkins of willows, which are purely female flowers, but he also obtained results when he used an extract taken from water lilies. This latter experiment calls to mind the poetic legend of the birth of Buddha, whose mother, according to an old Indian tradition, conceived at the touch of a lotus flower. Prof. Zondek has obtained his results only with extracts made from the sexual parts of plants; extracts from the vegetative portions are without effect.

Two other physiologists, Prof. Dohrn and Dr. Faure, of Vienna, state that they have performed similar experiments with an extract of yeast, which is a microscopic plant that normally reproduces without any sexual process whatever.

These rejuvenation experiments on females by means of various extracts are regarded here as of great importance, inasmuch as the female glandular mechanism is far less susceptible to surgical treatment such as the Steinach operation, than are the sex glands of males, hitherto the only beneficiaries of scientific efforts to restore youth. Glandular extracts provocative of sex reactions in the male, analogous to those already well known for female reactions, have so far been unobtainable; so that surgical treatment for males and glandular extract treatment for females are regarded as having reciprocal value.—*Science News-Letter.*

THE CHEMISTRY OF POWER.

By B. Clifford Hendricks,

University of Nebraska.

There are various notions of power. To many it suggests some mysterious, inexplicable quality which renders its possessor superior to his fellows. Such phrases as: "power from on high," "hypnotic power," "magical power" and "mental power" all carry something of this meaning. Without attempting to pass judgment upon the reality of this *mysterious* quality; power does not have that meaning for the scientist or engineer.

The world is interested in getting things done. To do something, especially to make changes in *things* requires, in the language of the engineer, the "expenditure of work." To do a week's washing requires work. To do a two weeks' washing requires more work. If the servant who does the washing is paid for it as a job, she is said, by the engineer, to be paid for her *work*. Under such an arrangement the employer is not much concerned with the time needed for doing the task. But in some homes this help is paid by the hour. There the lady of the house often works with her laborer for by so doing she not only makes the relationship of capital and labor a personal one but discourages "time service" as well. The engineer says to this home maker, "You are not buying *work* but rather you are paying for *power*." Thus it is seen, when time is required in measuring off the work, these work-time quantities are called *power*.

If the servant could, continuously throughout the day, do the equivalent of lifting a fifty-five pound tub of water two feet high every one-fifth of a second, she would be rated as a one-horse-power. Humans do not work continuously at a fixed rate. Machines have the advantage upon that score. Hence it is readily apparent that a *power* unit is a very convenient way of describing the industry of our mechanical servants such as: the vacuum cleaner, the washing machine and the electric fan. We want to know how much work the gas engine can do but we also want to know how fast it can work as well. We wish the electric motor not only to turn the wheels of the sewing machine but to turn them a desirable number of times per minute.

No *changes* can be made without work being involved. Changes in substances are no exception to this rule. In fact it has been found that every chemical change either uses or produces work.

A few evenings ago some aluminum powder was mixed with some iron rust and the mixture set off by the aid of flashlight powder. Over two hundred people in the chemical lecture room of the University of Nebraska held their hands before their eyes to shut out the blinding light produced. After the flare had died down the lecture assistant held up a plate of one-fourth inch steel and showed the hole that the hot product of the change had melted in it. He said, "It was over 3,000° F. hot." The new substance, iron, was redeemed from the iron rust during the change but the spectators thought not of it but only of the flare of light and the intense heat. They were impressed with the energy released by the change.

Often the work or energy produced is worth more than the new substances made. When coal is burned in the stove we know that about twelve tons of air are required for each ton of coal burned and over thirteen tons of smoke are produced. No one is interested in the smoke except as how best to get rid of it, but everyone is much concerned with the heat this change produces. If the coal is anthracite of average quality we know that the ton will produce enough heat to melt 875 tons of ice. Or to put it another way, besides making ashes and smoke this change in one ton of coal furnished energy enough to lift itself 618 miles high. Coal, as we all know, is not a pure substance but rather a mixture, sometimes containing such incombustible materials as slate and soapstone. Since this material will not burn it will not produce heat. This is one reason why some coals, such as high grade bituminous, will produce more than twice as much heat per ton as low grade lignite. The question is often raised by the home maker, "Should I buy a cheaper grade of fuel to use during the early spring weeks when but little fire is needed?" One item to consider, after cleanliness and ease of starting have been recognized, is "what are the relative heat quantities produced by the standard and the cheaper grades of coal?" High grade soft coal or a semi-anthracite coal will, ton for ton, produce more than twice as much heat as low grade lignite. Obviously one could ill afford to pay more than half as much per ton for the low grade lignite.

If the fuel is a pure substance the amount of heat produced is just as definite as are the quantities of new substances. A pint of grain alcohol will, when burned, give about a half pint of water (.464) and sixty-five and one-half cubic feet of carbon

dioxide gas, but at the same time it will produce exactly enough heat to melt 727.25 pounds of ice or one-fourth enough energy to do a week's washing for a family of five. If wood alcohol were used, a pint would produce only three-fourths as much heat. In other words, if the substance to be burned is known the chemist can at once tell how much heat a given weight of it will produce. This is a perfectly general rule whether the change occurring is one of burning, souring or any other transformation in substances. There must be the transformation, however, or the energy is not forthcoming. Unless coal is allowed to sift through the grate it is all foolishness to talk of burning ashes. They cannot be further transformed by burning and without the transformation no heat is to be expected.

Most all small home lighting units are provided with a battery of lead storage cells. By their aid electrical power is available for washing machine, sewing machine and lights, even when the generator is not running. But these cells must be watched. They are said to discharge. When the hydrometer shows a drop in reading there must be a recharge. What has actually happened is a chemical change between the acid in the cell and the materials of the plates, lead and lead dioxide. The acid has been consumed and has produced a white powdery substance called lead sulphate upon each plate. When these plates become alike no electrical energy can be obtained. Here is another case where the new *substance* is of no particular value but where the power produced, electrical power, is of first importance. A recharge is a very fine illustration of a chemical change where energy is *consumed*. This consumed energy is used in producing new substances; pure lead at one plate and lead dioxide at the other. This is not a storing of electric energy. It is rather a transforming of electric energy into chemical energy. Thus it is seen that one kind of energy may be transformed into another kind just as one sort of substance may be transformed into another. In this, the amount of energy transformed bears a definite relation to the amount of substance changed.

When the plated silver-ware has worn through, a replate represents again this interrelationship between electric energy consumed and weight of silver plated. In fact the cost of plating is a payment for energy as well as a payment for the metal. Such electrically-driven chemical changes are quite common in

the industrial world. They include the production of such substances as: hydrogen and oxygen by the electrolytic decomposition of water, the electric refining of metals, electrotyping and electro-plating.

Perhaps the most important of all changes in substances are those taking place within our own bodies. Here we are scarcely conscious of the change of foods; fats, starches, sugars, and proteins, into living tissue, yet it occurs. It scarcely seems possible that the eight-pound babe should in a year's time treble its weight. Yet we know such is the case. Again we are likely to overlook the energy accompaniment of these changes. We know the child's body must keep warm. This heat energy as well as the energy for the child's movements comes from the food during its transformations in the baby's body. So well does the up-to-date physician and food expert recognize this relationship that tables have been worked out, for their use, for all the principal foods. These tables show the exact quantity of energy to be expected from a given amount of all the different foods. During the World War much attention was given to the "caloric value of foods." The housewives were enjoined to buy their family's food, as I have suggested that coal be bought, for its energy or power value. Food experts are, now, no longer talking food values so much in those terms. They say, "The 'power' value of a food is only one of its qualities to be considered. The changes the food itself undergoes in the body, the new substances it produces, as well as the influence of one food upon another all need to be taken into account."

The time was, and not many years ago (1869), when much of the world's work was done by power developed in man, i. e., by the food he ate. At that time, one-third of the power of this country was furnished by this method. By 1919, or fifty years later, however, his energy furnished but one-fiftieth of Uncle Sam's power. It is estimated[1] that today, out of all the power available in our country, there is enough to provide the equivalent of 50 slaves for every man, woman and child. You may look about in vain to see some of these servants in your own home. Yet hold just a moment! Today, instead of rubbing an Aladdin's lamp, you step to the wall of your house. You press a button or turn a small crank and some energy or power from a dry cell, and produced by a chemical change, spirits itself through a wire. At its destination this electric energy rings

[1]Science, 62, 381-384 (1926).

a bell and another servant, this time a man, answers your call. This man has at hand, ready for your use, foods, drinks, dress and luxuries prepared by hundreds of servants either human or machine. At a word from you and presently, whatever you wish, there it is at your door.

You may wish to call upon a friend. The same messenger will call the auto-bus to your door or you may use your own car. You step in and sit down upon its cushions, you turn a switch and by so doing start a chemical change in your auto's storage battery. The power from this change cranks your engine which is another way of saying, starts a chemical change between some gasoline and air in the engine cylinders. Sooner than it takes to say it, power from that chemical change is turning your car's wheels towards your friend's home.

If you find the friend in the dairy house you may learn that the cows are milked by a machine run by power from a gas engine, power produced by changing air and gasoline into carbon dioxide and water. That the separator which skims the milk, as well as the churn which makes the butter are worked by the same power, and that if the milking, by chance, happens to be after dark, the turn of a switch floods the barn with light from power, *again* from a discharging storage battery. After all, moderns have many servants. And they also have the advantage of pre-civil war slave owners in that they do not have to have these servants around except as they are needed.

It is of more than passing interest to know the source of this great power at America's command. One-thousandth or one-tenth of one percent is furnished by the wind, about two-hundredths or two per cent from water falls and ninety-seven and nine-tenths per cent from burning coal, gas and other fuels or from *chemical* changes. Coal, gas and petroleum supplies are limited. The time will undoubtedly come when other chemical sources of energy must be found. While it is estimated that our present use of water power could be increased fourteen times, chemical change, even after that improvement, would still be the major source of energy. While we look to the engineer to use the power with the least possible waste, we are turning to the chemist to find the fuel substitute for the disappearing coal and gasoline. Will he try to use alcohol or will it be some other compound which will yield a maximum quantity of power with a minimum number of objectionable substances produced by the chemical change? No one knows, but

there seems to be promising possibilities in utilizing sunshine as the source of the energy to be transformed by plants into chemical energy, which in turn may become mechanical power.

A VISITORS' LABORATORY OF PHYSICS.

By Wm. S. Franklin,

Massachusetts Institute of Technology, Cambridge, Mass.

Every High School teacher of physics could arrange sets of simple experiments each of which could be left standing for several weeks in his laboratory and class rooms so that his students and occasional visitors could see some of the most interesting things in physics with a minimum of trouble and expense. It is intended to publish a series of short articles describing the most suitable experiments for the visitors' laboratory.

1. Use a low pivoted stool with ball bearings. Stand on the stool with arms outstretched and have a helper set your body rotating slowly. Draw in your arms and your speed of rotation is greatly increased. The effect is much more striking if you hold weights in your hands. An interesting example of this effect is furnished by the ballet dancer who while facing her audience turns rather slowly with arms outstretched but who very greatly increases her speed of rotation while her back is towards her audience by bringing her hands and arms in close to her body. Try the experiment and see how very short you can make the time during which your back is towards your audience.

Explanation: With your arms outstretched and holding weights, your helper has to put forth a very considerable effort to set you rotating at a certain speed; and when you draw your arms in your speed increases to what would have been produced by your helper if he had put forth the same effort on your body with your arms drawn in! The physicist introduces an important concept which he calls *spin inertia*[1] in connection with this experiment, and the product Ks, of spin inertia K and speed of spin s, he calls *spin momentum*. Now the spin momentum of a rotating body never changes unless a turning force is exerted on the body. After your body has been set rotating the Ks of your body remains unchanged if the stool is frictionless; but you can greatly decrease the spin inertia K of your body by drawing in your arms, and therefore, if the product Ks is to be constant, the speed s at which your body turns must increase.

[1]In fact, the physicist uses the ridiculous word *moment of inertia* not the more intelligible term *spin inertia*.

2. A bowl with a central hole in the bottom (stopped with a cork with a slender rod as a handle) is filled with water and the water in the bowl is set rotating by stirring. Pull out the cork and the speed of rotation of the water in the bowl is very greatly increased as it flows radially towards the central hole. Explanation same as 1.

3. Spread a thin layer of water on a very clean horizontal glass plate, and let a drop of alcohol fall on the middle of the plate. The surrounding water draws itself away from the spot where the alcohol is dropped, leaving a nearly dry spot there. The surface tension of the surrounding pure water is much greater than the surface tension of the alcohol-water mixture, and because of this greater surface tension the surrounding water draws itself together and away from the central spot.

4. Having a thin layer of lard or oil in a small frying pan, hold the pan horizontally and heat one part of the bottom of the pan over a Bunsen burner. The surface tension of the surrounding cool lard is much greater than the surface tension of the hot lard and the result is that the lard pulls itself away from the hot spot and leaves the hot spot nearly free from lard.

5. Place clean fresh water in a clean basin and skim off the surface layer of the water by pouring a little of the water over the edge of the basin, blowing the surface of the water towards the overflow. This leaves the surface of the water in the basin extremely clean. Then scrape fine shavings off a lump of gum camphor with a knife and let them fall on the clean water surface. The fine camphor shavings dart about on the water surface in a most remarkable manner. Explanation: the gum camphor dissolves very slowly in the water and the surface tension of this solution is much less than the surface tension of the pure water. The shavings are sure to be somewhat sharpened on one side and rounded on the other side, the gum camphor dissolves more rapidly at the sharpened point than at the rounded side, so that the surface tension is decreased more near the sharpened point than near the rounded side, and the greater surface tension near the rounded side pulls the camphor shaving along. Cut a minute boat out of clean cork (3-8 inches long by 1-8 inch wide), cut a fine slot in the stern, insert a shaving of camphor gum in the slot, and place the boat on the water in the basin. The surface tension of the water near the stern is lessened by the dissolving of the camphor gum so that the greater surface tension of the water at the bow pulls the boat along. If the basin is filled

heaping full so that the water surface turns down at the edge of the basin the boat will rebound from the edge and continue to travel round and round the basin. In making the cork boat, have the hands perfectly clean. If you touch the water surface in the basin with your unwashed finger the motion of the camphor chips and the motion of the cork boat will be greatly reduced, and several contacts of fingers with the water surface will kill the motion entirely because of the trace of oil that spreads over the water surface from the fingers.

5. Place half-a-teaspoon-full of a mixture of finely powdered galena (or finely powdered iron pyrite) and fine sand in a tumbler of water, add a drop or two of pine oil, and stir violently with an egg beater. The oil covers the particles of galena (or pyrite) and causes air bubbles to cling to them so that when the mixture is allowed to stand the particles of galena (or pyrite) float and the particles of sand sink. This is the celebrated "oil floatation process" which is now extensively used for separating metal ores from rock.

Pine oil is perhaps the best oil for this purpose, but if pine oil cannot be obtained turpentine can be used.

FUNDAMENTALISM AT DES MOINES.

During the summer months a merger of Drake University with Des Moines University was made effective and the new institution became subject to the fundamentalist group known as the Baptist Bible Union of North America. Members of the faculty were summoned to appear before a committee of the newly organized board of trustees who questioned them regarding their religious views and demanded that each member of the faculty subscribe to the confession of faith of the Bible Union consisting of eighteen articles. The committee announced that there would be no teaching of evolution, of higher criticism of the Bible, nor of naturalism as opposed to supernaturalism, and that no one would be permitted to teach in any department whose teaching would deny the divine inspiration and infallibility of the Bible as the word of God. Members of the faculty who refused to surrender their independence of thought and teaching were informed that their services were no longer needed regardless of the fact that some had contracts which will not expire for several months. Some of those who were dropped from the faculty or resigned because of the intolerable conditions are Professor Howland Hanson, Professor Phyllis Spencer, Professor Norma V. Sheidemann and Professor N. M. Grier. In all about twenty members of the faculty severed their relations with the institution.

This is not only a severe blow to the progress of science but a challenge to the teaching profession. It makes a teacher's contract another one of those "scraps of paper" that are of no value if the party in power chooses to disregard it.

SOME REACTIONS REGARDING THE PUBLISHED INVESTIGATIONS IN THE TEACHING OF SCIENCE.

II. The Curricular Studies.

By Francis D. Curtis,
University of Michigan.

The purpose of this paper is to present some of the more important impressions gained from an analysis of the curricular studies,[1,2] in the teaching of science, to list and describe the more important types of curricular studies, to mention some of their more striking values and defects as revealed by the published reports, and briefly to discuss the present status of investigation in its relation to future research in this field.

McCall states, "Except for sporadic cases and for continuous overlapping, the determination of truth has passed through three stages,"[3] authority, speculation, and experimentation. From the very beginnings of curriculum construction in elementary and secondary science, there has always been authority; more recently, there has been speculation, characterized by much discussion of sequence, course content, etc.; but only within about the last twenty years has experimentation, more or less scientific, begun to develop in this field.

Curricular studies in the teaching of science may roughly be classed with respect to technique employed, in three main groups, *Committee Reports Upon Aims and Course Syllabi*, *Questionary Studies*, and *Analyses*.

Committee Reports can scarcely be considered as research, since for the most part they express merely subjective opinions, and embody, or at least usually reveal, little or no experimental technique; their influence and value, moreover, are certain to decrease in proportion to the increase and development of scientific curricular investigation.

Questionary Studies are rapidly decreasing in influence and importance, because of the subjective factors involved, both in the responses and the interpretations of these responses. They are coming, moreover, to be used chiefly for securing opinion where it is really opinion that is wanted regarding the desirability

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[1]By curricular studies in this discussion is meant all "those studies which emphasize the materials which should be considered or stressed in teaching science. These studies involve the determination of aims underlying the teaching of the subject, the determination of curricular trends, and the actual selection of materials for inclusion or emphasis in the curriculum." Francis D. Curtis, *A Digest of Investigations in the Teaching of Science in the Elementary and Secondary Schools* (Philadelphia: P. Blakiston's Son & Co., 1926), Preface, p. v.

[2]For digests of forty-four curricular studies published prior to 1925, see Curtis, *op. cit.*

[3]William A. McCall, *How to Experiment in Education* (New York: The Macmillan Co., 1923), p. 1.

of certain materials, or aims, or practices, devices, etc.; or for securing data revealing curricular trends, sequence of courses, order of topics, etc.; or for determining actual practice with respect to such items of interest as subject-matter elements taught, laboratory methods used in presenting certain specified materials, teaching time devoted to certain elements or to laboratory work and recitation, etc.

Analyses, while far less numerous than either committee reports or questionary studies, are relatively and potentially of far greater value as sources of objectively determined criteria and data. This paper, therefore, will be devoted to a very brief discussion of the various types of published analyses relevant to the science curriculum in elementary and secondary schools.

For convenience in discussion, it seems desirable to consider these studies from the standpoint of the *sorts of information sought in the analyses* rather than of the materials analysed in seeking this information. The investigations seem then to fall into the following more or less distinct groups, though several might logically be classed in more than one of these groups:

1. Analyses to determine the aims which govern, or which should govern the teaching of the various branches of science;
2. Analyses to determine the subject-matter elements and essentials which are being taught;
3. Analyses to determine the relative importance of topics as indicated by teachers' stress;
4. Analyses to determine the appropriateness of teaching materials to the pupils for whom the materials are intended;
5. Analyses to determine scientific interests;
6. Analyses of children's knowledge of, and reactions to biological factors in their familiar environments;
7. Analyses to determine the sorts of scientific knowledge demanded as equipment for efficient living.

A brief discussion of these seven groups follows:

1. *Analyses to determine the aims which govern or which should govern the teaching of the various branches of science* include analyses of prefaces to textbooks, and of materials in professional books, bulletins, and magazines. The importance of aims, as indispensable guides to instruction cannot, of course, be questioned; and hence those investigators whose exhaustive analyses of available materials have yielded authoritative lists of aims, have doubtless performed a worthy service.

But now that the teacher knows what these aims are, he scarcely knows what is to be done about them. He regards them as ideals, as goals of instruction; but as yet, with respect to most of them he can only *hope* that his teaching achieves them; he has no means of *knowing* that it does. The adequacy and effectiveness of materials and methods, alike, remain as yet to a major extent undetermined.

After the aims as defined have been generally accepted as more or less definite goals of instruction, therefore, the worker in science education can insure their ultimate attainment only by first defining more specifically, both the fields of subject-matter and the materials of instruction which may contribute to their accomplishment, by then determining the classroom activities appropriate to their realization, and finally by inventing dependable objective tests for measuring their attainment.

2. *Analyses to determine the elements of subject-matter which are being taught* include analyses of textbooks, outlines, and syllabi. Usually it is also the purpose in such studies to ascertain the relative importance of the various elements of subject-matter, by determining the actual amounts of textual matter, or of illustrations, or of both, devoted to the various topics.

The results of these investigations are certain to be more or less subjective: No two analysts of the same materials would distribute them under exactly the same headings; the more inclusive and consequently the fewer these headings, the greater, of course, would be the chances of agreement, but the less useful and actually indicative for curricular purposes the data would be. Webb[4] and Trafton,[5] for example, in their analyses of textbooks in general science, are in close agreement as respects the percentage of total space devoted to the major divisions; but it is certain that their distributions of the material among several hundred headings would disagree at many points.

The data from such studies are undoubtedly of considerable value. But there are at least two reasons why these data should not be permitted to exert too strong an influence upon course construction: First, the same educational inertia and conservatism which impel most teachers to teach only what is in the textbook, may lead them to consider that what has been taught from text-

[4]Hanor A. Webb, *General Science Instruction in the Grades*, Contributions to Education, No. 4, Nashville, Tennessee: George Peabody College for Teachers, 1921.

[5]Gilbert H. Trafton, "Comparison of Textbook rule in General Science," *General Science Quarterly*, IV (1920), 450-54.

books is the material which they should continue to teach; such an idea obviously offers little hope for curricular progress and improvement. Secondly, the mere knowledge that certain subject-matter elements are receiving major stress in the more widely used textbooks in a given subject is in itself no significant reason for assuming that these same elements are especially well suited to particular types of pupils or to particular localities.

3. *Analyses to determine the relative importance of topics as indicated by teachers' stress* have thus far consisted chiefly of analyses of College Entrance Examinations Board questions and of term examination papers, although, of course, analyses of textbooks, outlines, and syllabi likewise reveal relative teaching stress. College Entrance Examinations Board questions are given first place in this class because of the unquestionably great influence they exert directly and indirectly upon teaching practice. Term examination papers are included because they are believed by some investigators not only to reveal the items most strongly emphasized in teaching, but also to indicate more truly than any other materials, those items which teachers believe to be of most importance and value in the courses they teach. There is some reason, however, to question the extent to which examination questions prepared by teachers, do actually reveal the topics which these teachers consider of major weight and worth: It is possible that the very potent, conservative influence of the College Entrance Examinations Board questions may compel many progressive teachers, as they doubtless influence textbook writers, to stress certain topics to an extent greater than the teachers' personal convictions of the actual values of these topics would justify.

These studies, too, are criticised as being subjective because, whether a given question belongs under this topic or another is largely a matter of the investigator's personal opinion.

4. *Analyses to determine the appropriateness of teaching materials to the pupils for whom the materials are intended* might be judged to include practically every type of curricular study. But two types seem to be aimed more directly at the solution of this problem than the others: (a) The determination of what scientific terms occur in the literature which the pupil is apt to encounter in his daily life, as an index of the terms with which his courses in science should make him familiar, and (b) the determination of the vocabulary difficulties of the textbooks which he uses.

(a) *Analyses to determine scientific terms* are subject to criticism on the grounds of the subjective factor involved in the definition of what constitutes a scientific term. One would say, off hand, that the connotation of any passage determines whether a given word in it is a scientific term. But the scientific connotation a passage has for any given reader depends largely upon that reader's scientific background. A chemist, for example, might not consider "Kangaroos" a scientific term in this sentence appearing in a newspaper article about Australia, "Kangaroos were numerous"; but a zoologist would at once recognize in "kangaroos," the name of a certain unique mammal or marsupial.

A further criticism of these analyses arises from the difficulty encountered in listing the scientific terms, since many are composed of more than one word, each of which by itself possesses a connotation totally different from that which it assumes when combined with the other or others. "Specific" and "gravity," for example, in certain contexts may each be considered a scientific term, but neither, when by itself, suggests the same meaning as "specific gravity"; hence "specific gravity" must be considered as *one* term and not two.

(b) *Vocabulary difficulties of textbooks* are determined usually with the aid of some standard word-list, as Thorndike's, *The Teacher's Word Book*. In these studies, "vocabulary load" is determined by a word-count revealing the number of words or terms in a given textbook which are not found among the most frequently used English words, as indicated by the criterion employed.

There can be little doubt that Powers' first vocabulary study[6] has exerted a wholesome influence upon all elementary textbooks in science which have appeared since the report of his investigation was published; and his more recent study[7] should possess even greater potential values for textbook writers.

5. *Analyses to determine scientific interests* are of several types: (a) The determination of interests as revealed by pupils' questions about, or reactions to, certain scientific objects form-

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[6] S. R. Powers, "The Vocabulary of High School Science Text-books," *Teachers College Record*, XXVI (1925), 368-82.
[7] S. R. Powers, "A Vocabulary of Scientific Terms for High School Students," *Teachers College Record*, XXVIII (1926), 220-45.

ally presented for their inspection; (b) as revealed by questions and observations voluntarily submitted by children to science "Question Box" departments of certain children's magazines; (c) as revealed by questions submitted by children or adults in response to the invitation to ask any scientific questions they please; (d) as revealed by the sorts of scientific topics discussed in the daily press, in current magazines, or books other than textbooks; and (e) as revealed by questions which children and adults spontaneously ask about scientic objects or phenomena.

(a) *Investigations of pupil reactions to scientific objects formally presented for their inspection* are clearly of interest and value. But caution must be observed in drawing inferences which may influence curriculum construction, from statements regarding the preference of boys and girls of certain school grades for certain physical, plant, or animal materials, when the children have reacted to only a few objects not known to be representative of these classes.

(b) *Studies of scientific questions submitted for publication in magazines* are open to two criticisms of considerable force: First, it seems likely that questions submitted with the hope that they will be published, will be artificial rather than spontaneous and natural; and secondly, the published questions are apt not to come from a representative sampling of children, because probably only superior children are capable of submitting publishable questions and observations, and because from all the questions submitted the magazines publish only a relative few, selected according to certain standards of their own.

(c) *Analyses of scientific questions secured from children and adults in response to a request for them* are censured chiefly on the score of the technique employed in securing the questions: In order to aid the subjects in understanding what is wanted, the investigator gives, along with the instructions, a number of model questions. These model questions are thought to exert too strong a suggestive influence upon the responses: The frequency with which these questions appear among the questions secured is thought to be excessive, as is also the number of questions intimately concerned with, or closely related to, the topics asked about in the model questions; but a recently pub-

lished study of this type[8] presents evidence indicating that the suggestive influence of the model questions is less potent than has previously been supposed.

These studies are open to criticism also on the grounds of selective sampling: The subjects of all, but one,[8] thus far published, were secured in good-sized towns and cities, for the possible reason that it is so much easier to secure a sufficient number of such subjects than to secure a like number of rural dwellers.

(d) *Determinations of the scientific topics discussed in newspapers, magazines, and books other than textbooks,* are of considerable significance, since the newspapers, especially, reflect the current interests of practically all literate individuals. Too much importance, however, should not be given the results of such studies, because of their necessarily limited scope, and of the fact that much of the material possesses ephemeral interest only, and may even have lost much of its significance before the results of the investigations have finally been published. Investigations of this type, moreover, are criticized as including an unrepresentative sampling of materials, and as being subjective with respect to assignment of materials to the respective topics.

(e) *Analyses of questions which children and adults spontaneously ask teachers and others* would seem to offer one of the best guides to the selection of curricular materials, provided there can be a sufficient number of such questions secured from a sufficient number of individuals to insure a representative sampling in representative situations and environments.

6. *Analyses of children's knowledge of and reaction to biological factors in their familiar environments* consist of studies of children's answers to lists of direct questions, or their responses to suggestions of various sorts. These studies, few in number and limited in scope as they are, succeed in emphasizing the paucity of children's knowledge of science, and in adding force to the contention that children should be given more contacts with scientific materials under controlled conditions insuring better organized and more accurate scientific concepts.

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[8]Francis D. Curtis, "A Study of the Scientific Interests of Dwellers in Small Towns and in the Country," *Peabody Journal of Education*, V (1927), 22-34.

7. *Analyses to determine the sorts of scientific knowledge demanded for efficient living* may include several types of studies considered here as belonging to other groups; but only a few investigations have yet appeared aiming directly at a solution of this very important problem. Harap's dissertation,[9] a study of commanding merit, and one analysis of the recorded applications of science which arose in the daily lives of a limited and highly selected group of individuals, practically comprise the list thus far reported.

This completes the very brief discussion of published studies here classed as curricular studies in elementary and secondary science. By way of summary, it may be stated that the *chief* criticisms which seem to apply to all, or to practically all, of these various types of studies are these: (1) Because of limited scope or for other reasons, each fails to secure either a representative sampling of experimental subjects or materials, or to reflect a typical situation or environment; and (2) the data and findings are certain to be more or less subjective. It should be kept in mind, however, that these criticisms are not peculiarly applicable to the studies in the teaching of science, but will be found to apply with equal justice to published curricular studies in other fields of education.

The first of these criticisms can be removed only by the extension of investigation along these and similar lines. The second criticism is the more serious; and it is the more difficult to remove because purely objective criteria, which must ultimately supplant subjective opinion and judgment in such analyses, have not yet been devised. This subjective factor can probably never be eliminated, but it may be greatly reduced by having several investigators analyze or judge the same materials independently; for, in general, the greater the number of independent judgments which agree with respect to any given point, the more convincing that particular decision becomes.

Valuable as these individual and collective investigations are, the curricular values of most of them have been greatly diminished by the manner in which the studies have been reported.

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[9] Henry Harap, *The Education of the Consumer* (New York: The Macmillan Co., 1924).

Judged from the standpoint of potential worth for curricular construction, a study becomes valuable to the extent that its readily available published report includes the detailed data. This statement means that a report of a study of interests should include a list of at least the more frequently occurring, if not all of the interests; the report of an analysis of textbooks into topics should include a detailed list of these topics. Writers of textbooks and syllabi derive little benefit from a report which merely states, for example, that a certain percentage of newspaper articles analyzed, dealt with radio, or that more scientific questions in a certain study dealt with astronomy than with any other subject. They need to know what phases of radio were discussed in the former case, and what topics of astronomy were asked about in the latter. Educational magazines must therefore be willing to publish more detailed reports of such studies than have been appearing; they must be willing, for the good of the cause, to devote sufficient space to such reports to enable the investigator to include at least a considerable number, of not all, of his lists of topics, or scientific terms, or interests, or what not.

But what is to be done with the already large and steadily growing number of curricular studies? Up to the present, practically no use whatever has been made of them in constructing saner and better curricula. New units have arbitrarily been added from time to time to the various science courses, but the older units still remain the standard course elements, having been subjected to little or no examination for the purpose of determining their relative or their continued appropriateness as materials of instruction. Even with so "new" a subject as general science there is evident a similar, possibly undesirable tendency toward standardization along the lines of course materials already in use.

There are doubtless potential values in every curricular study, but the criterion of whether the study was worth the making and the reporting must ultimately be measured in terms of the use made of its findings. Each analysis, then, if worth while, should contribute some valuable information regarding topics of prime importance to a greater or smaller section of society; a combination, then, of the curricular elements gleaned from a sufficiently large number and variety of studies should give for each branch of science at least a small and tentative list of

"minimal essentials," which the average prospective citizen should know from a study of that science. The standardized courses in these various sciences should then be revised if, as seems probable, revision should be necessary to insure that they embody the appropriate minimal essentials as a core. Thus the cumulative results of the curricular studies would be made a safeguard against undesirable or too great standardization, and would indicate not only the extent to which revision might be necessary, but also the points at which, and the materials with which, the revision should be made. Eventually, though this is not so much the problem of science teaching in the elementary and secondary schools, a sufficient number of studies should reveal in addition to the minimal essentials, specific elements essential as foundational materials to each of the various vocations.

It is time, therefore, that the writers of textbooks or syllabi began to take account of the data of all the available studies. Many difficulties, of course, confront the one who attempts to carry out such a plan—that, for example, of assembling all of the pertinent studies; and the further difficulty, when once this assembling has been effected, of determining the relative weightings of the various subject-matter elements revealed—the question of whether a certain topic gleaned from one study is worthy of more or less emphasis in a certain course than another topic taken from a different study; the subjective factor must necessarily bulk large in the attempt toward an objective synthesis of course materials, but the results of such an attempt can hardly fail to make practicable, better courses than the present ones, constructed as they are on the basis of authority, dictated by precedent.

Increasing values should be found in subsequent curricular investigations since research technique in the curricular, as in the learning investigations, is improving. Recent studies are correcting one by one the more flagrant defects of earlier ones. But improvement in any trial and error process in a new field is necessarily slow, and here may be hastened and insured only if the research is carried out or directed by trained educational specialists, who know both the field and the methods of curricular research thus far employed.

A promising beginning has been made in the studies thus far reported; but these must be repeated, extended, and elaborated indefinitely. "Job analyses" for the purpose of attempting to

determine the essentials of physics, chemistry, biology, etc., which are apt to prove of greatest value to the farmer, the housewife, the mechanic, the lawyer, and all the rest, must be made along with a wide assortment of investigations of the scientific materials essential or contributive to a keener and more intelligent enjoyment of the ever increasing variety of leisure pursuits. Thus, as the number and variety of studies increase, a more and more authentic list of "minimal essentials" will gradually be determined for the various sciences taught in elementary and secondary schools, a list which to become and to remain valid must undergo constant scrutiny and revision in the light of every new published report as it appears.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

Being some observations of the great and the near-great on the nature of the several sciences and on the art of living in general, preserved occasionally without prejudice but reproduced always with mental reservations.

By Duane Roller.

For science is, like virtue, its own exceeding great reward.—*Charles Kingsley, English clergyman and writer.*

If a little knowledge is dangerous, where is a man who has so much as to be out of danger.—*Thomas Henry Huxley, English biologist, in Science and Culture.*

To despise theory is to have the excessively vain pretension to do without knowing what one does, and to speak without knowing what one says.—*Bernard le Bovier Fontenelle, French author who was pronounced by Voltaire the most universal genius of his age.*

The narrow sectarian cannot read astronomy with impunity. The creeds of his church shrivel like dried leaves at the door of the observatory. —*Ralph Waldo Emerson.*

There are truths which are not for all men, nor for all times.—*Francois Marie Voltaire, French philosopher, dramatist and man of letters, in a letter to Cardinal de Bernis, 1761.*

The physicist attempting to construct an atomic model from considerations of spectral data has been compared to a man who, never having seen a musical instrument, should essay to construct a model of a piano by listening to the sounds made by it when thrown down stairs.—*Edward Neville da Costa Andrade, English physicist, in The Structure of the Atom, 1923.*

> Th' invention all admir'd, and each how he
> To be th' inventor miss'd; so easy it seem'd,
> Once found, which yet unfound most would have thought
> Impossible!
>
> —*John Milton in Paradise Lost.*

It is a common and pathetic spectacle to see military, political, and social leaders who come conspicuously into the public gaze, lose their sense of perspective and begin to regard themselves as holding a commission from the Almighty. I have never known a great scientist to make that blunder. And there ought never to be one who makes it because the business of science is to see things as they are.—*Robert Andrews Millikan, physicist, in an address delivered at the National Museum in connection with the presentation of a gram of radium to Madame Curie, 1921.*

SOME NEW-TYPE TEST FORMS IN HIGH SCHOOL PHYSICS.

By Hans C. Gordon,

Central High School, Philadelphia, Pa.

In spite of the large number of forms which new-type tests take, the principles involved in the question forms are usually recognition or recall of facts. The recognition types contain the answer in the question, the selection of the proper response indicating the mastery of the facts. The recall types require a more complete mastery, in that the answer must originate in the mind of the person being tested.

This distinction, while helpful, is not final nor absolute. Most forms can be placed in one category or the other, yet there are some which contain the elements of both. Also, it is often a simple matter to change the form of a question from one of these general types to another.

1. Multiple-choice questions are quite varied. The usual type is a statement which is finished by a number of expressions from which the examinee chooses one only. The number of expressions given is important. If only two choices are given, half the answers would be guessed correctly on the basis of pure chance alone. On any other basis also, a large percentage of unknown answers will be marked right. With three alternatives the score would show one right out of every three where the answer was guessed, and so on. That is, in a fifty question five alternative, multiple-choice test, if the answers to thirty questions were definitely known, it is probable that he would get four of the remaining twenty right, although the possibility exists that he might get all right or twenty wrong. Five alternatives are believed to be a satisfactory number for most purposes. The ordinary multiple choice question of this type is illustrated here:

Write the number of the correct answer in the column to the right.

The intensity of light varies 1. Directly as the Distance; 2. Inversely as the Square of the Distance; 3. Inversely as the Square Root of the Distance; 4. Directly as the Square Root of the Distance; 5. Directly as the Square of the Distance. Ans.———————

2. A problem may be given or a question asked and the answer included in a list of items following.

How much current would be used by a 21 C. P. lamp, which had an efficiency of 0.7 C. P. per watt in a 6 volt circuit? a. 3 ohms; b. 14.7 amperes; c. 5 amperes; d. 4.2 volts; e. 1.8 watts; f. 126 volts; g. 2 watts; h. 3.5 ohms; i. 0.5 watts. Ans.———————

In a question of this type the use of a multiple-choice form of answer is only justified in its ease of scoring. A large number of

alternatives is included to reduce possible correct guessing.

3. Multiple-Choice selections may be given to fill in missing words in a sentence or paragraph as follows:

The principle of 1. Archimedes; 2. Conservation of Matter; 3. Pascal; 4. Boyle; 5. Charles. Ans.———

states that when a body is immersed in a 1. Gas; 2. Liquid; 3. Fluid; 4. Water; 5. Mercury. Ans.———

it loses in weight an amount equal to 1. The Weight of the Body; 2. Volume of the Liquid; 3. Volume of the Body Displaced; 4. Weight of the Liquid Displaced; 5. Weight of the Water. Ans.———

4. Occasionally we wish to measure fine discriminations between possibly right answers, so as to pick out the best answer, as in the case stated above "when a body is immersed in a gas; liquid; fluid; water; mercury." Any one of these may be legitimately counted correct, but number 3, fluid, is the most general and in this case, the best answer. In giving directions for this type of question, it is wise to say that the answer wanted is the "best" or "truest."

5. A way to greatly increase the number of questions or parts of questions is to give a multiple-choice statement which has more than one correct response.

Cross out the wrong answers.

The idea of surface tension of liquids is used to explain the following phenomena: The Round Shape of a Bubble; Waves on the Ocean; The Action of a Lift Pump; The Cartesian Diver; The Spinning of a Small Grain of Camphor on the Surface of Water; The Height of the Barometer.

The possibility of including both correct answers here without actually knowing them is only one in eleven.

6. When we wish to measure the ability to select and relate items, we might use the form of multiple-choice test which has multiple choice items in both the subject and the predicate. These items must be combined correctly.

Place the number of the best answer in the column to the right

1. The Usual Starting of an Automobile from a Dead Stop to a Speed of 30 Miles Per Hour; 2. The Falling of a Stone is an example of 3; Uniform Motion; 4. Non-Uniformly Accelerated Motion. Ans.———and———

There is only one possibly right combination, 1 with 4. On the basis of pure chance there is only one possibility out of four of a guessed answer being right, although there are just two alternatives in each part.

7. A form of multiple-choice question which has many advantages is to describe an episode and give a number of explanations from which to select the best.

Give the number of the best explanation.

A boy weighed his fish by hanging it on the end of a fishing pole and two pounds of salt on the other end. He balanced the pole and thought the

fish weighed two pounds. He was disappointed when he found that the fish actually weighed one pound.

1. The fish lost a pound on the way home.
2. The grocer gave him short weight of salt.
3. He should have balanced the pole first and taken moments.
4. He should have made sure that the lengths from the fish and the salt to the balancing point were equal.
5. He should have known the weight of the pole.

Ans.———————

8. Thought questions may be of this type:

What is wrong with this statement?

We cannot speak of the density of air, because air is so light that it doesn't have any density. Incorrect because:

1. Air sometimes becomes cloudy.
2. Air is sometimes so heavy that it makes smoke fall.
3. What its weight is does not have anything to do with it.
4. Air does have weight. Ans.———————

9. Matching terms is a form of recognition question, easy to prepare for some types of work, and easy to score. It also has the advantage of having but a small element of chance in the score.

Put a number after the name in the first column which will show with what topic of Physics his name is connected.

Millikan	———	1. Law of volumes and pressures of gases.
Boyle	———	2. Basic law of electricity.
Archimedes	———	3. The law of elasticity.
Ohm	———	4. The law of the conservation of energy.
Joule	———	5. The law of the pendulum.
Helmholtz	———	6. The electron.
		7. Mechanical equivalent of heat.
		8. Freely falling bodies.
		9. Bodies immersed in liquids.
		10. Fundamental laws of resonance.

This same type of question can be used in matching lists of facts, of cataloging facts in the proper department of Physics, of equations, etc. A device which is not so valuable as a testing, as a teaching device, is to distribute cards containing either half of an equation. For example, on one card the letter "S" would be drawn, and on another the other term of an equation, such as "$\frac{1}{2}$ at^2." A large number of cards would be thus prepared, and used to play a form of "Old Maids" in which the effort would be to mate the terms.

10. The group type of recognition question has some decided advantages in testing information and reasoning power. There are three general types of group questions. First, a list of terms is given, all of them belonging to the same group except one. This one is to be identified. The basis of classification may be given or not, according to the wish of the examiner. In the following example the basis is given:

Give the number of the one that does not belong.

The following metals are non-magnetic:

1. Silver; 2. Platinum; 3. Lead; 4. Copper; 5. Tin; 6. Nickel; 7. Zinc; 8. Gold. Ans._____

The basis of classification may not be given.

Give the number of the one term that does not belong to the list:

1. Index of Refraction; 2. Resonance; 3. Angle of Incidence; 4. Normal; 5. Convex; 6. Concave; 7. Virtual; 8. Inverted.

Ans._____

11. Second, a list of words containing some which ought to be classified together is prepared, the idea being to identify those which belong together. Group name may or may not be used.

Cross out the wrong words.

The following units are used in making measurements of forces: Inches; Yards; Pounds; Foot Pounds; Grams; Kilograms; Kilogram Meters; Horsepower; Pounds per Cu. Ft.; Pounds Per Sq. In.; Grams Per C. C.; Liters; Dynes.

When the group name is not given it is important to make it impossible to group those which do not belong to the group we want together, or the question would be ambiguous. The above question would not suit without the group name. Here is one without the group name.

Cross out any term that does not belong in this list.

Permeability; Lines of Force; Mechanical Efficiency; Kinetic Energy; Magnetic Field; Critical Angle; Manometric.

12. The third type of grouping is an arrangement with a missing member. The most satisfactory form of this question has a recall rather than a recognition ending. Here is the recognition type.

Cross out the wrong answers.

The five divisions of Physics are: 1. Heat; 2. Light; 3. Sound; 4. Electricity and Magnetism; 5. Hydraulics, Phonetics, Mechanics, Levers, Optics, Tuning Forks.

13. The "arrangement-in-order" question requires a type of thinking frequently required in everyday life, often neglected in school. Here a different type of knowledge is required:

Place a 1. before the smallest, a 2. before the next larger and continue until all are numbered.

( ) Gram; ( ) Pound; ( ) Ounce; ( ) Kilogram; ( ) Metric Ton; ( ) English Short Ton.

Scoring technique here requires that the sum of differences between the correct order and the order being scored be taken and interpolated so as to stand in relationship to the scores of other parts of the test. The larger the sum of differences the smaller the positive score.

14. The "true-false" question, often believed to be representative of all the new-type questions is probably the most frequent type. The ordinary form of true-false test consists of a number of statements which may be either true or false, this being indicated in a number of different ways. The words themselves, or abbreviations, or symbols (plus and minus signs or plus and zero signs) are written before or after the statement; or prepared columns, headed "True" and "False," are checked.

Cross out the wrong letter given before this statement, T if it is not true, and F if it is not false.

T F The volume of a gas at constant temperature varies directly as the pressure.

Various modifications of the true-false test which probably improve it are given. A column is added to indicate the state of knowledge, as being doubtful, positive or purely a guess. If the test is going to be used to rate the student, it throws a great deal upon his honesty. The true-false test may be used as a direct check upon a given piece of work, as a reading assignment or a problem, and given in connection with it. Both old and new types may be benefited by combining a true-false test with a space for the reason for the answer.

15. The addition of a third column to the other two has some advantages. This column may be used for the word "Undecided." This would probably lead to a smaller amount of guessing, because with only the two alternatives, a student must either guess or leave the question unanswered if he does not know. "Either true or false" is another suggested heading for the third column. In this case another type of statement may be prepared which may be either true or false.

16. Carrying this idea further in copy of Watson's[1] "degree-of-truth" test, prepare a system of symbols to represent:

1. So true that no one with a fair understanding could sincerely and honestly believe it false.
2. Probably true or true in a large degree.
3. Uncertain or doubtful.
4. Probably false or false in a large degree.
5. So false that no one with a fair degree of understanding of this subject could sincerely and honestly believe it true.

It is true that a scale of truth of this kind has less utility in Physics than it might have in social sciences, because of most statements in Physics, it can be said that they are either definite-

[1]Watson, G. B., "Measurement of Fairmindedness." Teachers' College Series, Contributions to Education 176, 1925.

ly true or definitely false, or they cannot be proved. On the other hand it must be admitted that there is some room for such a scale, especially when the statements are framed from explanatory theories.

A word or two as to the advantages and limitations of the true-false type may not be amiss, in that this particular type is often taken as representative of all the forms of the new-type test. This form has had to bear the brunt of the attack upon chance answers. This is as it should be. While it remains in its present form, guessed answers are bound to compose a rather large proportion of the results. However, there are some definite advantages of the true-false test which must not be overlooked. First it requires a definite decision, usually without delay. Practice of this sort is very valuable. Second, there is a very decided time economy in grading by the use of stencils or mechanical devices. Third, they are almost completely objective. Fourth, more questions per unit of time make for a more thorough sampling than any other type. It is probable that study habits will tend toward applications rather than mere memorization of facts, because true-false tests often involve a high order of thinking. There is probably more pleasure in taking a test of this kind than any other for the average student. The question is not whether the true-false question is perfect or very faulty, but does it add anything to our testing power.

17. The use of sketches, charts, diagrams, maps, photographs, and other visual aids, even apparatus and material has many advantages. Visualization by sketches, whether poorly made or not, adds in making the test less abstract, and less difficult for the average student. It measures a different thing then, to ask what principle Fig. 1 illustrates or who was the first man to perform the experiment shown in Fig. 2.

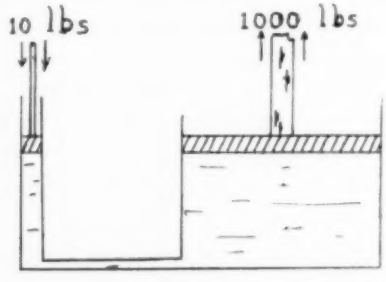

FIG. 1.

FIG. 2.

18. A rapid, easily scored method of giving a test using sketches is to give out a list of names of apparatus, instruments, experiments, etc., with an identification number for each. As each sketch is exhibited its identification number is written on the papers. Apparatus, instruments, and charts can be shown in the same manner.

19. Force diagrams lend themselves naturally to the addition of lines on the paper to a diagram partly completed.

Show by a line drawn to scale at the proper angle the resultant force in Fig. 3.

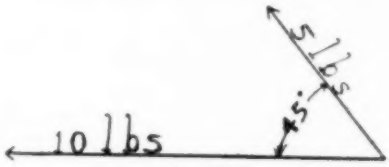

FIG. 3.

20. There is a challenge in the "What is wrong?" sketch, that makes motivation easy.

Sketch the necessary corrections in Fig. 4, and Fig. 5.

FIG. 4.

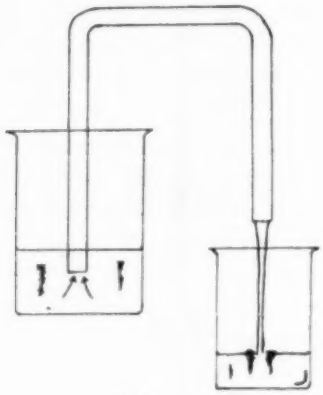

FIG. 5.

21. What is missing? This variation of the type just preceding often measures a kind of "Physical" intelligence left neglected in many other forms.

Sketch the missing rope in Fig. 6.

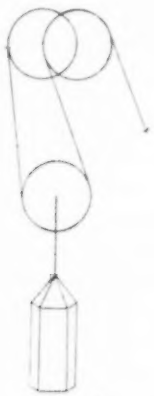

FIG. 6.

22. Reading of measurements is an exercise, often neglected, that can be applied to vernier, micrometer, barometer, thermometer, balances, etc.

Read this English Micrometer setting, Fig. 7. Ans._____

23. Multiple-choice in sketches.

Cross out the sketch showing the differential pulley with the smaller mechanical advantage, in Fig. 8.

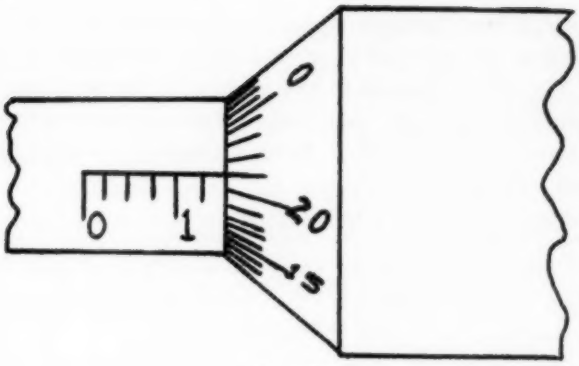

FIG. 7.

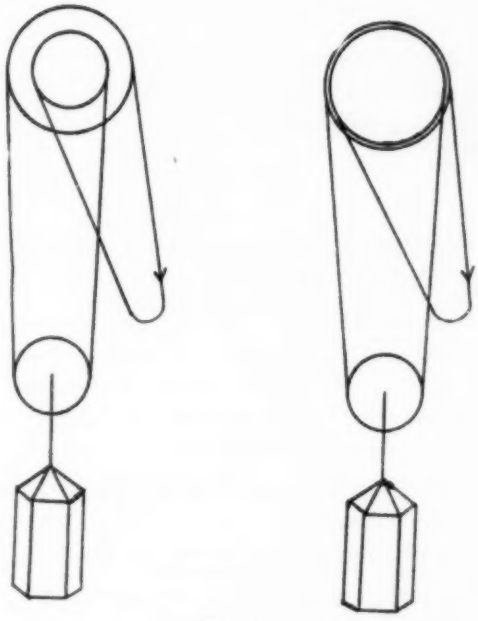

FIG. 8.

24. The simplest type of recall question, consists of an interrogative statement requiring a very brief answer usually a single word or a number.

What is the unit of heat in the English System? _____

25. Another type of recall question is the completion statement. The key word is left out in the following:

An amalgam is the union of any metal with _____.

The blank is best located at the end of the statement, because the question appears only after all the information has been given. The use of blanks in the middle of the statement makes it necessary to go back, and makes the question more difficult. This is sometimes desirable. Here is a completion question with the blank within the sentence:

The moment of a force is found by _____ the force by the perpendicular distance to the point where the force is acting.

26. There may be more than one blank in a sentence, or a paragraph may be given with a number of blanks, provided the sense is not lost, as in the following:

In musical tones the vibrations are perfectly _____ while_____ are vibrations of all kinds mingled together. The pitch of a musical note depends upon the _____ of the vibrations, while its loudness varies with the _____ of the vibrations.

27. The tabular form of completion question is economical of test paper space and may be represented as follows:

Supply the missing information in this density table:

Mass	Volume	Density
10 grams	1.5 c. c.	_____?
500 lbs.	_____?	125 lbs. per cu. ft.
_____?	1 cu. yard	62.4 lbs. per cu. ft.

28. The columnar form has somewhat similar characteristics, as shown by the following condensation:

Give a name for each of the following expressions:

$PV = P'V'$ _____

$F = \frac{M_1 M_2}{d^2}$ _____

$I = \frac{E}{R}$ _____

29. The completion of equations can be a matter of the insertion of terms or signs, as:

For fluids, pressure expressed in pounds per sq. ft. is found by multiplying the height of the fluid in ft. by the _____ in_____. This is also expressed $P = h$ x_____?

The power equation is P = F _____ D _____ T where the proper signs must be inserted between the terms.

There may also be a missing number, as in this question:

_____? = Mass x Acceleration.

30. Keeping in mind that the skillful teacher will wish to vary the difficulty of the questions in any given test, a device for lessening the difficulty of the completion type question may be in order. One device is to give the initial letter of the missing word as follows:

The weight of a body can be found by multiplying its volume by its d_____.

31. Another device is to indicate the number of letters in the missing word by using a dotted line with a dot for each letter, or bracketing a number at the end of the space or a combination of both. The following question illustrates the combination of these two:

The unit of electrical conductance is the . . . (3)

32. The "reasoning-by-analogy" question involves a type of mental activity which is probably somewhat different than the response awakened by many other questions. Its application in Physics can be shown by the following:

Boyle's Law is to the volume and pressure of a gas as Charles' Law is to its _____ and _____.

33. The "species-genus" type brings out classifying ability which it may be desirable to measure. The following question in tabular form illustrates the point:

Name the machine element of which the given object is an example:

Name of the object	Machine element
Crowbar	_____?
Capstan	_____?
Block and tackle	_____?
Jackscrew	_____?

SUMMARY.

Thirty-three variations of new-type questions have been collected from the literature of the field, and illustrated by subject matter chosen from the field of high school physics. These varieties are roughly classified into recognition and recall types. Among the recognition types, eight forms of multiple-choice questions, one form of matching terms, three forms of "grouping" questions, one form of "arrangement-in-order" question, and three forms of true-false questions are listed. Seven ways of making use of visual material are indicated. Ten recall forms are given.

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MAPS ARE DICTIONARIES OF LATITUDE.

The topographic maps made by the Geological Survey of the Department of the Interior show by means of contour lines, of which there are thousands on some maps, the altitude above sea level of every portion of the area represented. In addition to portraying all physical characteristics, as well as the works of man, these maps therefore constitute a wonderfully detailed dictionary of altitudes, showing the height of every hill and slope. As the United States becomes more and more completely mapped the scope of this "dictionary" constantly expands. At the present time a little more than 40 per cent of the United States is topographically mapped, but the work is progressing rather slowly at the rate of only 17,000 or 18,000 square miles a year. Moreover, the maps of a large part of this area are either very old and therefore somewhat crude or else on so small a scale as to be inadequate for present-day needs. In addition therefore to areas that have never been surveyed there are considerable areas that will have to be resurveyed.—Department of the Interior.

THE NORM OF SOCIAL UTILITY IN COMMON FRACTIONS.

By George W. Myers,

The University of Chicago.

Much is being said nowadays on the public platform and written in the pedagogical literature for teachers of public school arithmetic about the need for restricting the common fractions employed in teaching this arithmetical topic to just those fraction forms that have been shown to have high social worth in commercial practice. Too often the very important and even very essential modifying clause, "or which are essential for other matters of arithmetic which have high social worth," is omitted from the restrictive statement to its very grave hurt. Immediately following the foreshortened form of statement of the so-called "principle of restriction" we are usually reminded with an air of overmuch implied, or explicitly asserted finality, that halves, fourths, eighths, thirds, fifths, tenths, and perhaps twelfths and sixteenths are the only forms which have social worth. We are therefore summoned to omit the consideration of other forms of the common fraction from our "modern" treatments for school children.

It is perhaps of interest to some readers to be reminded that current attempts to limit the field of common fractions to those forms that occur frequently in the affairs of the daily life of the average citizen, is only the reaction to the over-elaboration of the topic of common fractions that cumbered the school texts of thirty or forty years ago. It is one phase of the mania for "elimination lists" for school arithmetic that was very prevalent until recently among educational experts of a certain type, or stripe. The strength of the popularity of these lists was about in proportion to its length and to the vividness of the boyhood arithmetical experiences of the expert who gauged its popularity. No topic appears more consistently and conspicuously in these lists for drastic contraction in scope than does common fractions.

For a considerable period until recently it was quite the fashion for courses of study in arithmetic to prescribe for teachers, "Use only fractions whose denominators are not larger than 16 in the 5th and 6th grade treatments of common fractions." It did not take long of course for the teacher to discover that she could not even add or subtract $\frac{1}{3}$ and $\frac{1}{8}$ without the use of 24ths, nor $\frac{2}{3}$ and $\frac{5}{12}$ without 60ths; nevertheless the prescription stood proudly forth for forensic exploitation and parade. Few

mere teachers had the audacity to brave the epithet "fossil" by pointing out the hopeless unworkability of the platform educational acrobat. The minor fact that ill-considered program fiats cannot be carried out is no deterrent to some program makers and program salesmen. The teacher finds it the part of discretion to be content with the inarticulate consciousness of "truth crushed to earth will rise again." This aspect of discretion incidentally is safer also for the meal ticket, for though the pedagogue may "not live by bread alone," he knows how short and swift the descent may be made to the circles that do so live.

Time is a great healer in the domain of love and also in education. In the course of time it became clear even to the program protagonist that the common fraction prescription simply could not be operated and he adroitly avoided defeat by the verbal legerdemain of changing it to the form: "In the treatment of common fractions in arithmetic use only the fraction forms that have social worth." This was a more resonant stricture, but soon it was revealed by "scientific inquisition" that the fractions of social worth were precisely the same old "fractions whose denominators are 16 or less," except that perhaps 7ths, 9ths, 11ths, 13ths and 14ths were of no social worth. This seemed to commend itself as a still closer restriction. Nevertheless, the same old thirds, fifths, eighths and twelfths were to be retained, to be added, subtracted, multiplied and divided and the same old impossibility of treating this limited field without some attention to "non-social" types remains to torment the teacher.

The point upon which we are here to insist is that whether the forms of fraction to be admitted to treatment be restricted in either the one or the other of the two stipulated ways, it is unavoidable that considerable study and practice be given to many fractions that are clearly of the *non-social* type, unless we broaden the concept of socially worthwhile fractions to cover such fraction forms as are needed to perform and check intelligently the basic arithmetical processes applied to division of whole numbers, with remainders, and applied also to the socially worthwhile types of fraction and mixed number.

Should not an arithmetical pupil be able to find how many weeks in 90 days, and express the quotient as $12\frac{6}{7}$ weeks, and then be able to multiply $12\frac{6}{7}$ by 7 to check his work? Should he not be able to find how many 30-day months in 263 days and then multiply $8\frac{23}{30}$ by 30 to check his work? If the remainder

had been 22, he would have to multiply $8\frac{11}{15}$ by 30, which is non-social fraction work. The former requires the "unsocial seventh" and the latter the 30th, and in the modified example, the non-social 15th and $\frac{11}{15}$. Should the pupil not be able to find how many 365-day years in 846 days, or in 1610 days and check his work? The former requires him to use the *non-social* form $\frac{111}{365}$, and the latter the form $\frac{322}{365}$. These two relatively simple problems require that he multiply mixed numbers involving these two non-social forms by 365. Of course reducing square feet to square yards nearly always leads to 9ths, and reducing cubic feet to cubic yards leads to 27ths, to say nothing about reducing square inches to square feet, or cubic inches to cubic feet, etc.

Again, should not a sixth grade pupil learn how to divide $3\frac{1}{2}$ by 9, which he is taught to throw at once into the form $\frac{1}{2}\times\frac{1}{9}$ requiring that he deal with the unsocial ninth? Should he not learn to perform, $9\frac{3}{4}\div 3\frac{1}{2}$, by throwing it into the product form $\frac{39}{8}\times\frac{4}{14}$? These surely are pretty simple samples, but they are sufficient to show that division by a very simple mixed number may require the use in the multiplier of the product-form into which such exercises are commonly put, fractions whose denominators are hopelessly unmanageable by a pupil who is held in his experiences to only the so-called *social forms*. *Division by a mixed divisor* demands considerable practice in non-social forms of fractions.

A third reason for some preoccupation with fractions of the non-social type is that pupils of the fifth and sixth grades should be taught to obtain averages, at least such simple cases as the average grades for classes of any where from a dozen to 40 members (perhaps even of 50 members). They should also be able to check their results intelligently. Pupils of these grades should be able to express these class averages either as mixed numbers, or as decimals. To do this will call for the intelligent use of any denominator from 12 to 40 or 50. Vastly the greater part of the fractions that would arise in this work of averaging would involve numerators and denominators that would constitute them fractions of the non-social type. The point to be stressed is that enough teaching and practice with the non-social type of common fraction must be given to make such problems meaningful and solvable with some degree of ease and confidence. This involves more systematic practice than a mere hap-hazard occurrence, now and then and here and there in the pupil's arithmetical experience.

Finally, in elementary science courses in weighing samples of soil, and in studying the constituent soil-types, the pupil is often required to use pretty much any small weight, such as 24, 30, 40, 50, units of weight of his sample and to take whatever weight the constituent turns out to have. To express this as a percent of the entire sample may call for almost any possible form of common fraction. The applications of fractions in buying and selling are but a very narrow field of use of the fraction, as one learns at once whenever he takes up almost any of the applications of arithmetic in actual weighing and measuring. Arithmetic, hamstrung with a social limitation determined almost solely with regard to commercial frequencies of occurrence, is just about as sterile a sort of arithmetic as the schools have ever undertaken "to put across."

For the sake of an all-around usable type of arithmetic in a liberally defined social field of usage, the really conscientious text will exhibit enough occurrences of non-social fraction forms to scandalize the "cut-and-curtail" reformer of school arithmetic who bases his judgment of "modernness" of treatment exclusively on the lack of non-social forms in his counts of frequencies of occurrence of fraction forms. Surely the conscientious author will and should count on thus scandalizing him. We are not appealing for casting the social norm into the discard, but rather for the fuller application of "the rule of reason" in applying the social norm to the field of the common fraction in school arithmetic. Remembering that the great desideratum is a *socialized arithmetic*, including division of whole numbers and checking, division by mixed numbers and checking, finding averages and checking, reducing a wide variety of common fraction forms to decimal and percentage equivalents, etc., we begin to realize why many of the recent authors of reformed arithmetics no longer teach arithmetic at all. It is simply because sanely socialized arithmetic has been lost to view in the struggle to apply artificially made social norms to specific detail. Hamlet has been dropped from the play.

It is commonplace to state that the common fraction has to a considerable extent given way to the decimal in most of the callings of today that make any considerable use of extended numerical calculations. Calculating machines have taken over most of the old-time drudgery of reckoning, but they have by no means dispensed with the human factor. We do not nowadays

need such a degree of skill in the manipulation of common fractions as was formerly thought necessary, and to a degree was necessary. While the type of calculating with common fractions that is needed by the man of the street of today is mainly mental, this is also true of arithmetical calculating in general. This does not prevent us from teaching to school children with great care column addition, long multiplication and long division of whole numbers. The fact that the longer calculations do not occur in every day life with a frequency at all comparable with the frequency of mental reckonings is not accepted by us as a sufficient reason for abandoning the teaching of the longer operations, for the reason that the longer calculations are of very great consequence when they do occur, and they do occur. Frequency of occurrence of life experiences is very far from a true measure of relative importance. We have colds often but the smallpox but once. We get married relatively infrequently, but do the household detail involved in the infrequent event very much more frequently. We must not too wholeheartedly take frequency of occurrence as the measure of social utility. Utility should be somehow proportional to the product of frequency of occurrence by weight of significance.

Let us then freely admit that the life need for fractions most frequently involves only such small fractions as are used in buying and selling, making change, figuring wages, and in the trades. Let us not forget however, that many non-professional callings require a good deal of measuring and reducing the measures where many varied forms of the common fraction arise to be dealt with without machines, even after all the struggle of the commercial world to reduce everything to standard sizes has done its best. One does not have to enter the realm of bizarre experiences to meet a need to find how many weeks in a given number of days, how many square yards in a given number of square feet, or of the number of cubic yards in a given number of cubic feet, and to check the involved processes. When the divisions cited above do "not come out even," the non-social 7th, 9th and 27th are to be dealt with. Since such non-social fraction forms can be most economically mastered right when the techniques applicable to the social forms are being learned, the non-social forms must be sufficiently interspersed with the social to produce the necessary degree of transfer to beget a feeling of ease and confidence of mastery. Again,

we say to judge a treatment of fractions as unsocial solely from the occurrence of a relatively small number of the non-social forms is educational *myopia*, which disease we must all attempt to keep from crippling socialized school arithmetic.

In conclusion, may we not agree that the subject matter of a sanely socialized arithmetic must include among a multitude of other things, enough breadth and range of material in common fractions to enable the average pupil on leaving the sixth grade to have reasonable control of the following fundamental techniques:

1. To divide intelligently any whole number by any three- or four-digit divisor, record the remainder intelligently as a part of the quotient, and to check the correctness of the work. This would seem to be one goal of good school arithmetic, new as well as old. It calls for multiplying by a mixed number, the fraction of which may have almost any two- or three-digit denominator. Remember that when the divisor is put under the remainder, the resulting fraction may be reduced to lowest terms, thus giving a very wide range of denominators.

2. To divide intelligently by a comparatively simple mixed number for divisor, and to check. The usual procedure here is to reduce the divisor to an improper fraction, and then multiply the minuend by it. One needs try only a few such mixed numbers as $6\frac{1}{4}$, $8\frac{3}{4}$, $7\frac{5}{16}$, etc., to see what non-social forms of fraction come from reducing these to improper fractions and inverting.

3. To calculate intelligently the average of a reasonable number of magnitudes and to check the work, even when the average involves an "ugly fraction." The reader may try it on the problem of finding the average rate of interest on 3 bonds at 7%, 5 yielding 6%, 8 yielding 5%, 4 yielding $5\frac{1}{2}$% and 3 yielding 4%. The same more childlike form of problem would be to find the average grade of a class of 23 pupils in which 3 made 70, 5 made 60, 8 made 50, 4 made 55 and 3 made 40.

4. To reduce any ordinary common fraction to its decimal or percentage equivalent and to check the work. Pupils should of course be able to express the result either as an approximate decimal or as a decimal with a common fraction appendage.

The foregoing four situations constitute a good part of the internal demand of a socially useful arithmetic. The operations themselves are of high social utility though many of the fractions to which they lead with such problems as life furnishes,

will almost certainly be of the non-social type. The point we are here trying to stress is that well-built texts will contain enough of the non-social type of common fraction to make a truly social arithmetic possible. The topic of fractions is in the arithmetic course not merely to enable us to use such simple fractions as life demands directly, but also to make it possible to do other important arithmetical things that are of high social utility. The topic has a *linkage* function as well as a bland social function.

MICROBES PRODUCE COPPER.

Copper is ordinarily thought of as one of our most valuable metals won from the earth through the skill of the miner and made into usable form by the metallurgist; but according to a recent report of the Department of the Interior, it now appears that metallic copper may be deposited—in relatively small quantities to be sure—through the action of bacteria.

During a survey of the region near Cooke, Montana, by the Geological Survey, spongy masses of native copper were found in the black muck of a bog. Several bodies of pyritic copper ore crop out about half a mile above the bog. This ore weathers rapidly, and the copper is removed from it in solution as cupric sulphate. Redeposition of the copper as native metal only in the black muck and in none of the gravels and sands in the vicinity was ample proof that something in the muck had caused the precipitation of metallic copper from the sulphate solution, but the identity of the precipitating agent remained to be determined. Consideration of inorganic processes was discouraging, but preliminary experiments with the copper-bearing muck led to more carefully controlled experiments which proved beyond question that the copper was precipitated through the agency of certain bacilli. These experiments are described in some detail in Bulletin 795-C, of the Geological Survey—"Organic Precipitation of Metallic Copper," by T. S. Lovering.—Department of the Interior.

REVISED ALPHABET.

"Revise the alphabet and save a billion dollars a year," advises Dr. Godfrey Dewey of Harvard University. Adoption of his proposed alphabet would save millions of tons of print paper, he declared. Huge sums would be saved in type composition. Typists could do their work in less time, as could letter writers. Readers would do their reading more quickly and the human eye would be among the agents benefited. Books and newspapers would be smaller and lighter. The general result would be a saving in materials and labor, which means a saving in time for everyone and everything connected with the preparation and reading of printed, typed or written pages, according to the plan. By introduction of this new alphabet fewer symbols would be needed to express a thought. Long words would be spelled with a few letters. Such a word as "through" could be expressed in the three symbols, while a single sign could be used for "the," which, Dr. Dewey said, takes up 7 per cent of all the words in "the printed page."—*Journal of Education.*

THE PLACE AND PROBLEMS OF CHEMISTRY IN THE HIGH-SCHOOL CURRICULUM.

By Morris F. Stubbs,

Tennessee Wesleyan College, Athens, Tenn.

Perhaps the most outstanding problem before educators today is that of curriculum revision. It has been shown repeatedly that the character of the high-school population is changing rapidly. More and more students are bulging the walls of already overcrowded high-school buildings. Naturally then, this large increase in numbers has brought about changes in the purpose and aims of the high school. This institution must now train the large percentage of its students for life, rather than for college entrance. The masses rather than the classes must be served.

The chemistry teacher, along with others, has been doing his best to meet the changing conditions. He has been striving to reorganize his course to better serve the growing and changing high-school population. In spite of such efforts however, it is disconcerting to note, among other things, that the reports of the United States Commissioner of Education show that chemistry is barely holding its own in percentage of students enrolled. True, many students have shifted to the newer sciences, such as general science, but nevertheless something must be wrong with the organization of the course or more students would elect to take it.

Again such studies as those of Powers show that students are not mastering the subject matter commonly taught in the high-school chemistry course. Either the subject matter is poorly taught or else we are teaching material which is uninteresting or too hard for the average high-school boy and girl.

What then are some of the outstanding problems which must be solved by the curriculum maker in high-school chemistry and what are some of the possible means by which the course may be organized to better fit present day aims?

In the first place high-school chemistry is still too largely under the influence of the college. As is well known the academy and later the high school grew out of a demand for a secondary school adapted to everyday needs. However the high schools, like the academies before them, soon drifted toward the college. The result has been that secondary schools have largely arranged their courses to prepare pupils for college entrance. The College Entrance Board has, until very recently, dominated the

situation and has in large measure shaped the chemistry curricula and the character of the teaching. Naturally then, in content, secondary school chemistry has tended to become a sort of abbreviated college course.

It is true that college dominance has resulted in many benefits. However the bad results have outweighed the good. Twiss[1] points out that college dominance has tended to cast all instruction into one mold, to overestimate subject matter and minimize training in scientific thinking and to discourage initiative on the part of teachers. It is encouraging to note, however, that secondary school teachers are writing more texts, there is less adherence to suggested syllabi, and instructors are turning more and more to a scientific study of their own teaching problems.

A second objection frequently raised against present day teaching is that it aims to turn out chemists rather than intelligent citizens. Certainly if chemistry cannot give the pupil an insight into the significance of chemical discoveries and an appreciation of the scientific method of thinking, then any subject matter mastered is largely useless so far as the average boy or girl is concerned.

How can this objection be met? Downing[2] thinks that we must select our subject matter so as to include: (1) only matter that is socially worth while; (2) only those topics which follow the native interest of the boy or girl; and, (3) only those things which lend themselves to our aims. Downing[3] further gives as the aims or ends of science teaching the following: (1) Science should give us an appreciation of our commonplace environment. (2) Science should give us new knowledge which can be applied to the various fields of human endeavor. (3) Science should give needed training in scientific thinking. Certainly no other course is better fitted than chemistry to give such useful information or such training in scientific thinking. Chemistry touches our lives in so many ways through its applications to industry, agriculture, home activities, medicine, warfare, and the enrichment of life in general, that to omit it from the curriculum would be to deprive the student of one of the most interesting and useful fields of human knowledge. When chemistry teachers in general organize their courses on the basis of such general aims as Downing has given, the objection that

[1] Twiss, Science Teaching, p. 188.
[2] Downing, Teaching Science in the Schools, pp. 86 ff.
[3] Ibid, pp. 66 ff.

chemistry does not aid in turning out intelligent citizens will not be justified.

Let us examine the typical chemistry course, to determine, if possible, what reorganization is most needed in order that the course be better adapted to our aims and needs.

The first third of the course usually consists largely of a development of chemical laws and theories. This material is by far the hardest and is usually the most uninteresting to the pupil. Too often the result is that the student tends to lose his initial enthusiasm for the subject, he becomes discouraged and comes to dread rather than enjoy the course.

In fairness to the pupil the subject matter should gradually ncrease in difficulty as the course develops. We must go from simple to complex. This does not mean that we will need to omit essential theory, but it does mean that we will need to put the easier things first and the more difficult later when the student is better able to master them. Of course we will not be able to develop the subject as in the past according to the method of the college professor, but there are other methods which are just as logical, at least from the high-school view point. The writer firmly believes that certain fundamentals are necessary for a proper development of the course, whether it be to prepare for college or for life. Chemistry without the understanding of certain fundamental laws and theories would not be chemistry. Such theories as the modern theories of ionization and atomic structure should be included by all means, for these are essential for an adequate understanding of modern day chemistry.

Moreover theories can be presented in such a way as to give the pupil an appreciation and understanding of the ways by which science develops. The student should be trained to think a theory through until he is satisfied that it is consistent and reasonable. If this is done a real feeling of accomplishment will result and interest will be sustained. The reading of some such book as Slosson's "Creative Chemistry," for enjoyment only, early in the school year will give the student an insight into the wonders of chemistry that will sustain his interest during the more difficult parts of the course.

It has been stated that so far as possible, the material presented should be of interest to the student. Why not start the course then with some subject in which the average student is

interested and with which he is somewhat familiar? At the beginning of the year the teacher can determine in a general way what the pupils already know about chemistry by giving a general information test and the knowledge thus obtained can be used as a basis for beginning work. An interesting and logical beginning might be made by starting the course with some such topic as fire, water, or with a brief discussion of some of the common metals. These topics lead logically to a development of oxidation and oxygen.

Another point at which interest commonly falls off is during the latter part of the second semester when the ordinary course is largely descriptive, including a mass of data concerning the metals and their salts, little of which is productive of thought stimulation. Such data is no doubt useful to the professional chemist and it may be useful in training the memory but it certainly does not lend itself to constructive scientific thinking. Careful use of the project method at this time will stimulate interest and will give training in working out practical problems in which the student is really interested. The project method, used with limitations, furnishes the teacher with one of the finest of tools with which he may overcome the criticisms that the chemistry course lacks human interest and does not emphasize the great influence of chemistry in modern life.

A further problem facing the curriculum maker in chemistry has to do with the year in which chemistry shall be taught in the secondary school. Available data show no schools where the course is not given in either the third or fourth years of the high school. The general tendency seems to be that of placing chemistry in the fourth year. This seems to be a good arrangement and there is perhaps no logical reason for a change.

This raises the question, however, in regard to the arrangement and content of the courses preceding chemistry. At present secondary school science consists of a disconnected series of subjects. If chemistry is to be given in the fourth year should it not make use of what science, if any, the student has already had and not repeat work already given in general science, for example? At present there is no such a thing as a connected science course. As Downing[4] puts it, "we have a series of science fragments offered in the schools but no science course." When high-school administrators and science teachers decide

[4] Downing, op. cit., p. 98.

as to what science and how much shall be required for graduation, we will be better able to solve this important problem.

The place of the laboratory in the chemistry course presents another very important problem from the standpoint of the curriculum. Inglis[5] states that the laboratory courses, as they have been given, have proved to be unattractive, although he admits that certain gains have resulted from the introduction of laboratory work. Inglis suggests that those pupils who are not interested in science work be allowed to take chemistry without laboratory work, or at least with very little.

Inglis is justified in saying that the laboratory work of the past has been uninteresting and too technical, but his plan of eliminating laboratory work is not sound. Observation plays a very important part in chemistry and the student cannot be expected to observe much about chemical substances unless he works with them. However, as has been pointed out many times we should not expect a student to rediscover everything for himself. The pupil could never do it and if he could it would be a wasteful process from the standpoint of time.

How may the criticism that laboratory work is uninteresting and too technical be met and how may laboratory work be made more profitable? In the first place an experiment should be given as the result of a definite problem which has arisen in the mind of the student. The pupil should go into the laboratory with a very definite idea as to the object of the experiment he is to perform. If this is done there will be a desire to solve the problem and interest will be sustained. Experiments for high-school pupils should rarely be of the quantitative type for such experiments are time killers and are usually too technical for the high-school boy or girl. The inclusion of such experiments accounts for a considerable part of the unattractiveness of laboratory work. Project experiments are especially useful in high-school work and the pupil should be encouraged to solve problems of his own, under the supervision of the instructor.

The laboratory note-book is another problem which presents itself. The requirement of long detailed notes often puts a "wet blanket" on the pupil's interest in the experiment. The writer has recently conducted an investigation[6] which seems to show that detailed laboratory notes are not necessary for retain-

[5] Inglis, Principles of Secondary Education, pp. 526 ff.
[6] Stubbs, SCHOOL SCIENCE AND MATHEMATICS, 26, pp. 233-240.

ing the main facts of the experiment or for proper training in scientific thinking and expression. The statistics seem to point to the fact that if the student answers well made questions which make sure that he has made proper observations and has reached correct conclusions on the basis of the observed results, he masters his laboratory work as well as when using the old detailed form of write-up. If some such method is used the laboratory note-book ceases to be a drudgery to both teacher and pupil.

Recent studies by Cunningham,[7] Cooprider,[8] and Anibal[9] seem to show that laboratory work can be given effectively by means of lecture demonstrations. This finding makes it possible for those chemistry teachers who do not have adequate apparatus to give efficient laboratory work by demonstration. This method is a time saver but has its limitations in that it fails to give training in manipulation. This difficulty may be partly overcome by allowing the pupils to assist the teacher or else by allowing groups of students to conduct the demonstrations themselves.

The need for changes in secondary school chemistry, which this paper has so far discussed, has been based on the premise that the Senior High School completes the so-called secondary school period. At present however there is a tendency to extend the secondary school level to the end of the junior college period. If this plan becomes general, then what is now high-school chemistry will need to be given as a general course to serve as a foundation for the advanced courses which the junior college will offer, as well as being a general cultural course.

If the later high school years and the early college years are to be brought together in a single institution, there will necessarily need to be a definite reorganization, in fact such a reorganization is already needed, to avoid wasteful duplication. What is needed is a carefully formulated set of minimum essentials to be given in the high school so the college instructors will not need to do the great amount of overlapping in first year college chemistry that Koos[10] shows they are doing at present. These minimum essentials should be such as will fit into a course given

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[7]Cunningham, SCHOOL SCIENCE AND MATHEMATICS, 24, pp. 709-715.
[8]Cooprider, SCHOOL SCIENCE AND MATHEMATICS, 22, pp. 838-844.
[9]Anibal, Masters Thesis, University of Chicago library.
[10]Koos, The Junior College Movement, pp. 275. ff

primarily for the large percentage of high-school students who will not go on to college. A great deal of work has already been done by various committees especially that of the American Chemical Society, attempting to work out some such scheme.

When a plan of this type is adopted, college instructors will know exactly what their first year students have mastered, and the college instructor can take up the study at the point where the high school left off. This plan of course presumes that the instruction in the high school be of a very high grade, an impossibility in many high schools where any teacher who happens to have a vacant period is assigned to chemistry. If the senior high school is linked with the junior college the problem will not be difficult to solve for the same teacher would in all probability, teach both courses. The writer has been privileged to teach with such an arrangement and finds it possible to build the freshman college course on the course given in the preparatory department. It is true that a certain amount of review is necessary to refresh the student's memory, but a topic actually mastered is soon recalled.

At present a considerable part of the first year college course is in reality a high-school course and those pupils who have had high-school chemistry repeat in large measure the work they have had the previous year. Some of the larger universities and colleges are giving separate courses for those who have had and those who have not had high-school chemistry. However at the end of the year both groups of pupils are usually put in the same advanced classes and both groups usually receive the same credit for the year's work, although one class has had by far the harder course.

The writer believes that those pupils who have had a course in chemistry in an accredited high school should be given an intensive half year's work in general chemistry, followed by a thorough course in qualitative analysis the second semester. Those students who have not had high-school chemistry should be given a full year in general chemistry, followed by qualitative analysis the second year. At present many colleges are giving only one-half year of fundamentals to those students who have not had high-school chemistry and are following this by a semester's work in qualitative analysis. However the writer is firmly convinced that the proper ground work for an adequate course in qualitative analysis can not be given in one semester. True, many engineering students must finish both

courses the first year, but such students should be required to present chemistry for entrance. The present common procedure has resulted in inadequate training in general chemistry and has developed a course in qualitative analysis that is hardly worthy of the name.

This paper has attempted to show wherein the present course in high-school chemistry is most in need of reorganization and how the problems presented may in some measure be solved. If the chemistry course can not be reorganized to accomplish our aims and to serve our needs better than any other science, it has no place in the curriculum of the high school. That the course can be so organized is the belief of most administrators and teachers of chemistry.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTIONS.

964. *D. Lawrence Barrick, Montezuma, N. Mex.*

Readers interested in Problem 956 will find a generalized solution by Nathan Altshiller-Court in the February, 1927, page 102, American Mathematical Monthly.

The "Cocoanut Problem" has come to life again. Michael Goldberg sends in the generalized solution taking care of odd and even number of cases. His final solution is

$$A=(-1)^{n-1}d^n-d+1+\left[c+\frac{1+(-1)^n}{2}\right]d^{n+1}.$$

SOLUTIONS OF PROBLEMS.

966. *Proposed by Norman Anning, Ann Arbor, Mich.*

Prove that if a triangle has two sides which are not equal its area can be increased without increasing its perimeter.

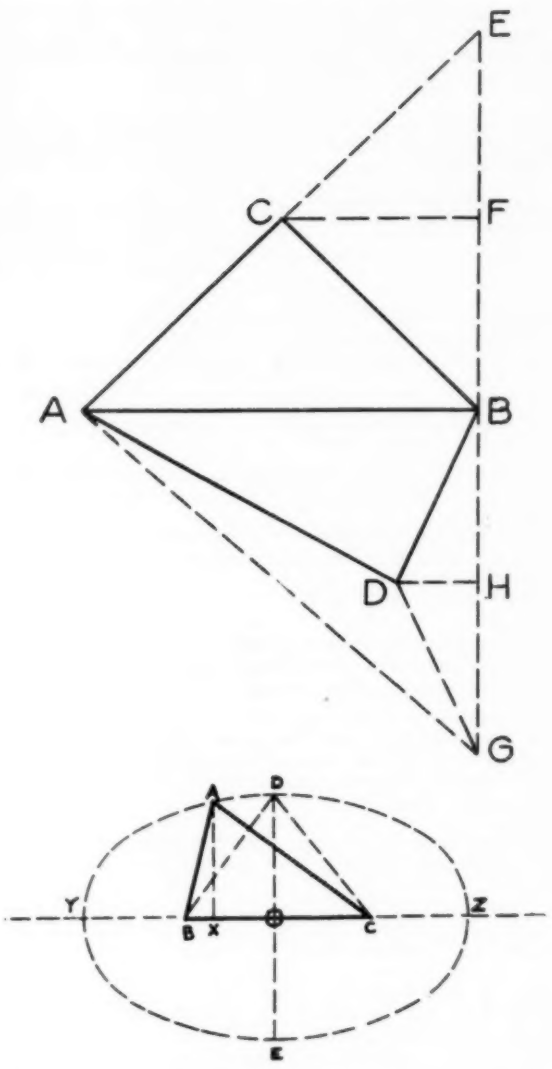
I. *Solved by Michael Goldberg, Washington, D. C.*

Let ABC be the isosceles triangle, and ABD any other triangle such that $AC+BC=AD+BD$. Produce AC to E making $CE=BC$. Draw BE, and CF perpendicular to BE. With radius DB, draw arc cutting EB produced in G. Draw DH perpendicular to BG. Draw AG. Then

$$AG<(AD+DG)=AD+DB=AC+CB=AE.$$

Hence $EB>BG$, and $EB/2=FB>BG/2=HB$. Therefore the triangle ABD is less than triangle ABC.

II. *Solved by Thomas Crenshaw, Jr., Culver Military Academy, Culver, Ind.*



GIVEN: The triangle BAC with AB and AC unequal sides.
PROVE: The area of BAC may be increased without increasing the perimeter.

1. Through A, with B and C as foci, const. an ellipse.
2. Prolong the base BC to meet the ellipse, thus forming the major axis YZ.
3. Bisect BC, thus dividing YZ equally, and draw the minor axis DE perpendicular to YZ.

1. Through one pt. to const. an ellipse, given the foci.
2. A st. line may be extended indefinitely, or limited at any point.
3. To erect the perpendicular bisector of a given line. The minor axis is the perpendicular bisector of the major axis.

4. DE is the longest line that can be drawn perpendicular to YZ, or OD is the longest altitude that any triangle inscribed in BDC can have
5. BC = BC.
6. The area of BDC is greater than the area of BAC.
7. The perimeter of BDC is equal to the perimeter of BAC.

4. The minor axis is the longest line that can be drawn perpendicular to the major axis of an ellipse.
5. Identity.
6. Two triangles having equal bases are to each other as their altitudes.
7. The perimeter of all triangles having the line joining the foci of an ellipse as a base, and their vertex inscribed in the ellipse are equal.

III. *Solved by J. Murray Barbour, Aurora, N. Y.*

Let a, b, c be sides of a triangle, and let $a > b$. Let $(a-x)$, $(b+x)$, c be the sides of a second triangle, having the same perimeter as the first. Then

$$\frac{A_1}{A_2} = \frac{\sqrt{s(s-a)(s-b)(s-c)}}{\sqrt{s(s-a+x)\quad(s-b-x)\quad(s-c)}}.$$

$A_2 > A_1$, if $(a-b) > x$. This limit would mean reversing the sides a and b. Practically $(a-b)/2$ is the limit, for beyond that point no new area values appear.

Hence, if a be decreased and b be increased by an amount not greater than $(a-b)/2$, the area of the original triangle would be increased without increasing its perimeter.

Also solved by *Smith D. Turner, Cambridge, Mass.; George Sergent, Tampico, Mexico.*

967. *Proposed by Smith D. Turner, Cambridge, Mass.*

Under what conditions can a number be equal to its logarithm?

I. *Solved by J. Murray Barbour, Aurora, N. Y.*

Let y be the base and x the logarithm. Then $y^x = x$, $y = x^{\frac{1}{x}}$. For all even, positive values of x, y may be either plus or minus; for all odd, negative values of x, y is the negative reciprocal of the corresponding positive value. If y is to be a real number, there will be no solution for even, negative values of x.

To find the maximum value of y, equate the derivative of $x^{\frac{1}{x}}$ to zero. To obtain the derivative, differentiate the identity

$$\log x^{\frac{1}{x}} = \tfrac{1}{x}\log x.$$

$$\therefore (1 - \log x)\ (x^{\frac{1}{x}-2}) = 0.$$

$$\log x = 1;\ x = e;\ y = e^{\frac{1}{e}}.$$

The following pairs of values show the general relation between y and x when both are positive.

$$y = 0,\ 1,\ e^{\frac{1}{e}},\ 1$$
$$x = 0,\ 1,\ e,\ \infty.$$

II. *Solved by Michael Goldberg, Washington, D. C.*

No real number is equal to its logarithm when the base is a real number. The equation $z = \log z$, where z is a complex number, has an infinite number of solutions. If the base is e, then $z = e^z$ or

$x + iy = e^{x+iy} = e^x e^{iy}$.

$x + iy = \rho e^{i\theta}$ where $\rho^2 = x^2 + y^2$, and $\theta = \arctan y/x$.

Hence $x^2 + y^2 = \rho^2 = (e^x)^2 = e^{2x}$ and $\theta = y$, or

$$\begin{cases} x^2 + y^2 = e^{2x} \\ y/x = \tan y. \end{cases}$$

These equations may be solved by trial for x and y. One solution is approximately

$$x=2.06 \qquad y=7.57,$$

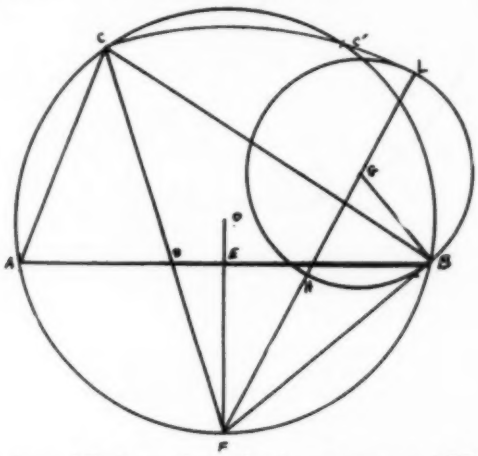
then $\log\ (2.06+7.57i)=\log\ \rho+i\theta=\log\ \sqrt{61.5074+i(74.8°+360°)}\frac{\pi}{180°}$
$=2.06+7.57i.$

Also solved by *George Sergent, Tampico, Mexico;* and the *Proposer.* The solution by the *Proposer* will appear in the pages of this Journal as a general article. It is worth reading by the student interested in analysis.

968. *Proposed by Walter R. Warne, University of Minnesota.*

Given the base of a triangle, the vertical angle, and the bisector of the vertical angle, to construct the triangle.

Solved by Smith D. Turner, Cambridge, Mass.



Upon given base AB draw circle O whose segment ACB shall contain the given vertical angle. Draw OEF $\perp$ to AB. Draw FB, and BG $\perp$ to BF, making BG = one-half the given bisector. With G as a center, and radius BG, draw circle cutting FG at H and L. With radius FL, draw an arc cutting circle O at C. Then ABC is the required triangle.

Proof. Draw CF, cutting AB at O. Since arc AF = arc FB, $\angle$FCB = $\angle$FBA; hence triangles FCB and FBD are similar. Then FC : FB :: FB : FD. Also since FC = FL, FC : FB :: FB : FH. Therefore FH = DF, and HL = CD.

Also solved by *Nathan Altshiller-Court, Univ. of Okla.; George Sergent* (two solutions), *Tampico, Mexico; Michael Goldberg, Washington, D. C.; R. H. Shanks, Culver Military Academy, Ind.; H. P. Scheffer, Culver Military Academy, Ind.; Daniel Kreth, Wellman, Iowa;* and the *Proposer.*

969. *Proposed by J. Q. McNatt, Canon City, Colo.*

Given a circle of radius R, and its inscribed Decagon and Pentagon. Prove geometrically that the square of the radius plus the square of the side of the Decagon is equal to the square of the side of the Pentagon.

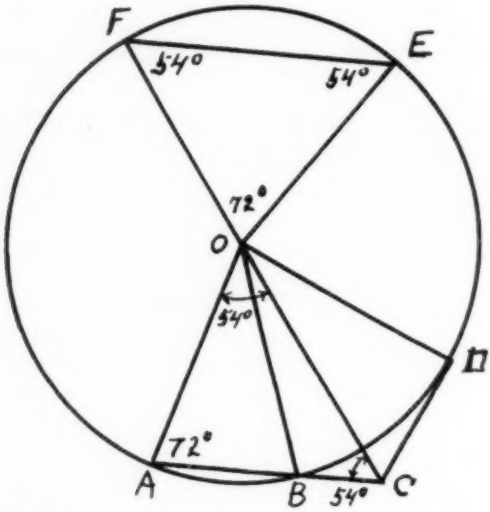
Solved by E. de la Garza, Brownsville, Texas.

AB is the side of the regular inscribed decagon; and FE is the side of the regular inscribed Pentagon. Produce AB to C, so that AC equals AO = R. Draw OB and OC. From C draw the tangent CD, and also draw the radius OD.

AB being the side of the decagon, and AC equal to the radius, AB is the mean proportional between AC and BC. Also, the tangent CD is a mean proportional between AC and BC. Hence, AB = CD.

Triangle FOE equals triangle OAC. Then OC = FE. For the right triangle ODC, $(OC)^2=(OD)^2+(CD)^2$, which proves the theorem.

Also solved by *J. Murray Barbour, Aurora, N. Y.; R. T. McGregor, Elk Grove, Col.;* and *R. E. Many, Cambridge, Mass.*

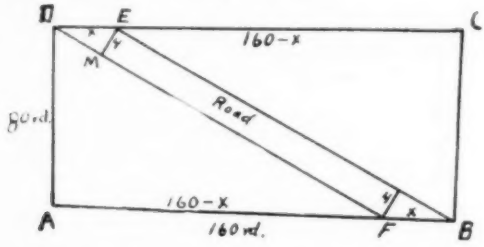


Editor: The other solutions mentioned gave the usual algebraic solutions as given in High School texts.

970. *For High School Pupils. Proposed by P. H. Nygaard, Spokane, Wash.*

A rectangular field has a straight road running diagonally across it. The road entrances are on the long sides of the field. The road has the shape of a parallelogram. Its width is 4 rods, and the field is 80 rods by 160 rods. How many acres in the field?

Solved by Watson Dalton, Okmulgee, Okla.



(a). By the equality of areas the value of x is determined.

Area of DEBF $=80x=4\sqrt{(160-x)^2+80^2}$.

Simplifying we get $399x^2+320x-32000=0$, from which we find $x=8.5634$ rods. Knowing the value of x the area of the field is found to be 75.718 acres.

(b). Setting up a proportion from similar triangles to find x.

Triangle DEM is similar to triangle EBC. Then we have $80/(160-x)=4/\sqrt{x^2-16}$. Simplifying we get the same equation in x as in (a).

Also solved by *Thomas Crenshaw, Jr., Culver Military Academy; Mervin Blume, Sterling, Ill.; Caroline McCallum, Spokane, Wash.; Earnest Davis, Murphysboro, Ill.; Louis Wides, Murphysboro, Ill.; George Sergent, Tampico, Mexico;* and the *Proposer.*

Editor. Several incorrect solutions were received.

Mr. George Sergent suggests the following general solution of the problem. If the length of the field is a, width of the field is b, width of the road is h, then the area of the field expressed in square units is

$$\frac{b^2(ab-h\sqrt{a^2+b^2-h^2})}{b^2-h^2}.$$

PROBLEMS FOR SOLUTION.

981. *Proposed by Daniel Kreth, Wellman, Iowa.*

The base of a triangle is 5, the bisector of the vertical angle is 4, and the vertical angle is 60°. Determine the lengths of the other two sides of the triangle, using an algebraic or a trigonometric solution.

Editor. The construction of the triangle is given in the solution of Problem 968 in this issue.

982. *Proposed by Nathan Altshiller-Court, University of Okla.*

If through the vertex of a triangle be drawn the median and a line parallel to the opposite side, these two lines determine a chord in the circumcircle of the triangle. Prove that this chord passes through the point of intersection of the tangents to the circumcircle at the other two vertices of the triangle.

Consider the three vertices of the triangle in turn and prove the three chords thus obtained are concurrent.

Prove that the common point of the three chords is on the *Euler* line of the triangle.

983. *Proposed by George Sergent, Tampico, Mexico.*

In a given sphere a circular cone is inscribed so that its lateral surface is equivalent to the lateral surface of one of the two spherical segments having the same base as the cone. Determine the dimensions of the cone.

984. *Proposed by R. T. McGregor, Elk Grove, Calif.*

Show that the sum of the products of every pair of the squares of the first n integers is

$$\frac{n}{360}(n^2-1)(4n^2-1)(5n+6).$$

985. *Proposed by E. de la Garza, Brownsville, Tex. For High School Students.*

Solve arithmetically. Two daily night trains run between Brownsville, Tex., and Houston, Tex. The first train leaves Brownsville at 6:20 p. m. and arrives at Houston at 7:20 a. m. of the next day. The second train leaves Brownsville at 7:45 p. m. and arrives at Houston at 7:30 a. m. of the next day. The rate of the second train is 3.04 miles more per hour than the rate of the first train. Find the distance from Brownsville to Houston.

SCIENCE QUESTIONS.

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DO YOU AGREE?

With the old experienced teacher who sent the following to the Editor: "I am sure teachers have many questions they would like to have answered but may be hesitant about sending them in fearing they are the only ones who do not know. Frequently questions like the ones below are sprung in groups of teachers and many of us are surprised to learn that no one is bold enough to answer. I am quite sure many teachers will be interested in the answers."

Please send in answers to the following questions, a part of which were proposed by the writer of the above. Also send in other everyday questions which you would like to propose or have discussed. If you wish your name withheld, just tell the Editor.

493. How does a mercury vapor rectifier work?

494. Should a small object to be viewed be placed at or within the principal focus of a lens that is used as a simple magnifier? Most text books say at the principal focus but give incomplete diagrams. Give diagrams.

495. Does the accumulation of hydrogen on the positive plate of a dry cell set up a back electromotive force (as stated in several textbooks of physics) or does it only decrease the e. m. f. and increase the internal resistance of the cell?

495. What is a "neon" tube? How does it work? What practical applications?

497. *Proposed by Smith D. Turner, Cambridge, Mass.*

Possibly you will find this question of interest: If a piece of cork is submerged in a bucket of water and released, it will rise to the top. But if at the instant it is released, the bucket is allowed to fall freely

(a) through the air

(b) in a vacuum

what will be the motion of the cork relative to the water?

EXAMINATION PAPERS.

COLLEGE ENTRANCE EXAMINATION BOARD

PHYSICS.

FRIDAY, JUNE 24, 1927. 2 P. M. TWO HOURS.

Answer ten questions as indicated below.

Number and letter each answer to correspond with the questions selected.

Indicate clearly your reasoning in each problem and state the units in which each answer is expressed.

PART I (*Answer all questions in this part*)

1. (*a*) Explain the difference between power and work.
   (b) A motor working at the rate of 20 horsepower hoisted a load of bricks 100 feet high in 2 minutes. How much is the load expressed in pounds?
2. A man wishes to lift a big granite stone, of specific gravity 2.5, from the bottom of a well. He can use a single fixed pulley but cannot lift the stone. A schoolboy suggests that, if the man will fill the well with water, he can then lift the stone easily. Assuming that the man can lift 200 pounds and the stone weights 250 pounds, prove that the boy is right.
3. A springboard over a swimming-pool is 15 feet long, is uniform, and weights 180 pounds. It may be considered as supported by two beams, being fastened to one at the inner end and resting on the second beam at a point 3 feet from the same end.
   (*a*) Find the magnitude and direction of the force on each beam when no one is on the board.
   (*b*) If the second beam is moved to a point 5 feet from the inner end, what will be the change in force exerted on it?
4. Explain the following facts:
   (*a*) Metals feel colder than wood in a cold room.
   (*b*) Ice is usually put in the upper part of an ice-box.
   (*c*) Fur-lined gloves are warmer than those with the fur outside.
   (*d*) A concave surface of polished copper is often placed back of an electric heating coil.
5. Show by diagram how eight 50-watt lamps would be connected on a 110-volt house circuit, including one ammeter so that it will measure the total current and a second ammeter to measure the current through one lamp only. Calculate the reading of each ammeter.
6. In taking a "sounding" on board ship by means of a sound wave generated just below the water surface, the echo reflected from the bottom of the sea is detected 1.5 seconds after the sound wave was generated. If the velocity of sound in water is 4720 feet per second, what is the depth of the sea at that point?
7. How far from a camera must a 6-foot person stand if a full-length

picture is to be obtained on a film 3 inches by 3 inches, the focal length of the camera lens being 6 inches?

PART II. (*Answer three questions from this part. No credit will be given for answers to extra questions.*)

8. A 160-pound man is standing on the floor of an elevator. Will his weight seem to be *less* than this, *more* than this, or *exactly this amount* under each of the following conditions:
   (*a*) When the elevator is rising with uniform velocity?
   (*b*) When the elevator is rising with uniform acceleration?
   (*c*) When the elevator is descending with an acceleration of 32 feet-per-second per second?
   Give fully the reasons in each case for your conclusions.
9. In some places the storage water tank set high in the air is being replaced by a tank at a lower height but with air under pressure above the surface of the water.
   (*a*) Explain the operation of such a system.
   (*b*) Compute the air pressure needed to give the same effect as an initial height of 40 feet.
   (*c*) Will an ordinary gauge indicate this calculated pressure? Explain.
10. The average pressure of steam on the piston of a double-acting steam engine is 130 pounds per square inch, the area of the face of the piston is 50 square inches, and the length of the stroke is 15 inches.
   (*a*) How much work is done by the steam in a single stroke?
   (*b*) What is the horse-power of the engine when the fly-wheel makes 60 revolutions per minute?
11. An electric toaster takes 600 watts at 110 volts.
   (*a*) At 11 cents per kilowatt-hour what does it cost to operate the toaster for 10 minutes?
   (*b*) Find the resistance of the toaster when hot.
   (*c*) How many calories are developed during the 10 minutes?

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12. Make a diagram of a simple battery-system telephone in which are used two transmitters with induction coils and two receivers. Explain clearly the conversion of the energy of speech into electrical pulses at the transmitter and back again into sound energy at the receiver.
13. (*a*) Describe an experimental method for finding the wave length of the sound given by a tuning fork of frequency 256.
    (*b*) From the data of such an experiment how may the velocity of sound be determined?
14. An incandescent lamp of the gas-filled type is rated at 0.70 watts per candlepower. What size of lamp, rated in watts, is needed to produce at a distance of 3 feet an illumination of 8 foot-candles?
15. (*a*) Which color in the spectrum has its light least refracted in passing through a prism?
    (*b*) Arrange the following in order of length of waves from longest to shortest in your list: violet light, red light, radio waves, X-rays, heat waves.
    (*c*) Show by a sketch a method by which the various colors of the spectrum may be assembled so as to produce white light.

SOLUTIONS AND ANSWERS.

487. *Proposed and answered by B. G. Spracklin, Instructor in Chemistry, Baron Byng High School, Montreal, Quebec.*

Supposing the specific gravity of copper is 8.8, a solid piece would of course sink in water, but by making a hollow ball of the right size, one could get it to float just as an ordinary tin pan floats on water. If the ball were made of 3 cu. inches of copper, how large would it need to be in order that it might float, and how large that it might float half out of water?

SOLUTION

Now weight of water as great as 3 cubic inches of copper would need to be 3 x 8.8 cu. in. of water. The copper in order just to float would need to be changed to this volume, in accordance with the principles formulated in the above article. The volume of the hollow globe would need to have a volume of 26.4 cubic in. If the copper is to float above the water, it must, as I have previously stated, displace its own weight of the liquid; that is there must be 26.4 cu. inches of the body in the water and since it is to be half out of water, the total volume is evidently 26.4 x 2 or 52.8 cu. inches. Many students who depend entirely on formulae would have a little difficulty in working this simple problem.

488. *From an examination paper set by the late Professor John Maddell, Ph.D., D. Sc.*

If ice floats with 1/10 its volume above the surface of the water, but in alcohol neither rises nor sinks no matter where placed below the surface of the liquid, what is the specific gravity of alcohol?

Solution by B. G. Spracklin.

Let the volume be $x$cc. and sp. g. of ice be y.

Weight of ice $= yx$ grams.

Weight of water displaced $= 9/10\ x$ grams.

$yx = 9/10x$, $y = 9/10$. Since block just floats in alcohol, sp. g. $= 9/10$ (i.e.) alcohol is 9/10 sp. g.

ARTICLES IN CURRENT PERIODICALS.

American Botanist, July, Willard N. Clute & Co., Joliet, Illinois. $2.00 a year, 50 cents a copy. The Cannon-Ball Tree by W. M. Buswell. Botanizing on Mt. Mitchell by Donald C. Peattie. Indian Pipe or Ghost Flower by Sadie U. Moore.

American Journal of Botany, July, Brooklyn Botanic Garden, Lancaster, Pa., $7.00 a year, 75 cents a copy. A Monographic Study of Special Groups of the Water Molds II. Leptomitaceas and Pythiomorphaceae by Bessie Bernice Kanouse, University of Michigan. Pollen-Tube Growth at Various Temperatures by J. T. Buchholz, University of Texas, and

A. F. Blakeslee, Carnegie Institution of Washington. The Development of the Macrogametophyte of Furcraea Andina by Beatrice I Nevins. Inheritance Studies in Pisum VI. Multiple Allelomorphim and the Inheritance of Green and Yellow Foliage and Pod Color by Dorothy I. Neff and Orand E. White, Brooklyn Botanic Garden. Acidification of *M* Unbuffered Salt Solutions by Plant Tissue, in Relation to the Question of Tissue Isoelectric Points by F. E. Denny and W. J. Youden, Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York.

American Mathematical Monthly, June-July, Menasha, Wis., $5.00 a year, 60 cents a copy. The Teaching of Mathematics in German Secondary Schools and the Training of Teachers for These Schools by Charles A. Noble, University of California, Berkeley. The Mystic Numeral by Harris Hancock, University of Cincinnati. Interpolation Formulas Dependent upon the Underlying Function by John F. Reilly, University of Iowa. Ruled Surfaces Referred to the Trihedral of a Directrix by Malcolm Foster, Williams College.

Condor, May-June, Bi-Monthly, Cooper Ornithological Club, Berkeley, Calif., $3.00 a year, 50 cents a copy. An Alberta Aviary by William Rowan, University of Alberta, Edmonton, Alberta, Canada. The Black Terns of Saskatchewan by H. H. Pittman, Wauchope, Saskatchewan, Canada. Seasonal Fluctuations in Bird Life in Central Oklahoma by Margaret Morse Nice, Norman, Oklahoma. The Falcons of the McKittrick Pleistocene by Loye Miller, Los Angeles, California.

Education, June, The Palmer Co., Boston, $4.00 a year, 40 cents a copy. The Things a Teacher Lives By by R. J. Gale, Bordentown Military Institute. The Objectives of Secondary Schools in 1926-27 by Carter V. Good, Miami University, Oxford, Ohio. Should the Junior and Senior High Schools Give Examinations? by J. S. Kinder, Pennsylvania College for Women, Pittsburgh, Pa.

General Science Quarterly, May, W. G. Whitman, Salem, Mass., $1.50 a year, 40 cents a copy. The Science Demonstration in the Junior-Senior

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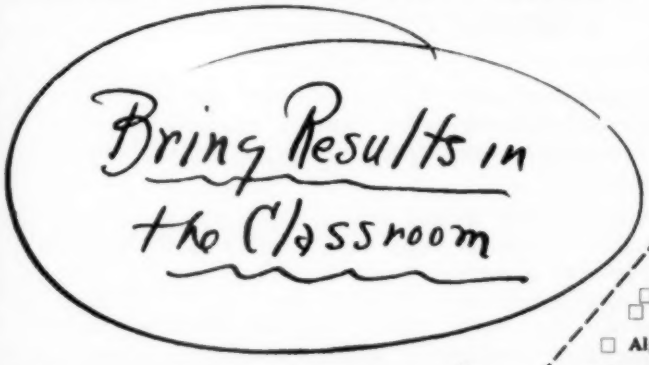

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Journal Chemical Education, July, Rochester, New York, $2.00 a year, 35 cents a copy. Millionths of an Inch by Guy Bartlett, General Electric Co., Schenectady, New York. The Beginnings of Leather Chemistry by F. L. Seymour-Jones, 358 Knickerbocker Road, Englewood, New Jersey. Cannizzaro and the Atomic Theory by N. Parravsvo, Instituo Chimico Della R, Universita Di Roma, Rome, Italy. The Nitrogen Problem in Agriculture by J. G. Lipman, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey. Ionization and the Atomic Structure Theory in Organic Chemistry by Roger J. Williams, University of Oregon, Eugene, Oregon.

Journal of Geography, May, A. J. Nystrom & Co., 2249 Calumet Avenue, Chicago, $2.50 a year, 35 cents a copy. Contribution of Geography in Senior High Schools by Albert Perry Brigham, Colgate University. The Republic of Austria by Alice M. Krackowizer, State Normal School, Salisbury, Maryland. First Lessons in Continent Study by Selma Abrams, New Orleans Normal School.

Mathematics Teacher, May, National Council of Teachers of Mathematics, Yonkers, N. Y., $2.00 a year, 40 cents a copy. A Riddle from Archimedes by George W. Evans, Houston, Texas. The Four Fundamental Arithmetical Processes in Adults by Inga Olla Helseth, Florida State College for Women, Tallahassee, Florida. A Mathematical Contest by Helen M. Walker. A Critical Evaluation of Individualized Instruction in Mathematics by Wilma Shaffer Flewelling, Emerson High School, Gary, Indiana. The Laboratory Method in Teaching of Geometry by C. A. Austin, Venice High School, Los Angeles, Cal.

National Geographic Magazine, August, Washington, D. C., $3.50 a year, 50 cents a copy. Across the Midi in a Canoe by Melville Chater. Navigating the Norge from Rome to the North Pole and Beyond by General Umberto Nobile of the Italian Air Force. Stalking the Dragon Lizard on the Island of Konodo by W. Douglas Burden. Air Conquest.

A LETTER TO YOU.

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Many requests have come to us recently asking that we publish more classroom contrivances, student stimulation stunts, recitation recreations, thought ticklers and dynamic devices.

What are some of the things you do daily that make your students like to be in your class? What do your pupils do that makes progress most rapid? How do you present the most difficult lesson of the semester? What review devices do you use? How do you make use of the play instinct in teaching? What problems interest your pupils? What questions do you ask? How do you ask them? In street language, how do you "do your stuff?" Tell others through the columns of SCHOOL SCIENCE AND MATHEMATICS.—The Editor.

Popular Astronomy, June-July, Northfield, Minnesota, $4.00 a year, 45 cents a copy. Isaac Newton and his Work in Astronomy and Optics by Ralph H. Curtiss. Report on Mars, No. 40, by William H. Pickering. A New Law of Planetary Distances and Orbital Velocities by Hsin P. Soh.

School Review, June, The University of Chicago Press, $2.50 a year, 30 cents a copy. Curriculum Revision and College-Entrance Requirements by William Martin Proctor, Stanford University. Science Department Meetings by Alexander Brodell, Franklin K. Lane High School, Brooklyn, New York. A Directed-Study Plan for Town High Schools by James T. Hamilton, Newberg, Oregon.

Scientific American, August, New York, $4.00 a year, 35 cents a copy. Our Worst Storm, the Tornado by Dr. W. J. Humphreys, United States Weather Bureau. Cipher Messages of the Stars, Henry Norris Russell, Princeton University. The Conquest of the Everglades by Arthur Woodward. The Most Fascinating Spot on Earth by D. Moreau Barringer, Jr.

Scientific Monthly, August, The Science Press, New York, $5.00 a year, 50 cents a copy. The History of the Alphabet by Professor Ingo W. D. Hackh, College of Physicians and Surgeons of San Francisco, Calif. Science and Religion by Professor I. W. Howerth, State Teachers College, Greeley, Col. A Summer on Logan River by Professor James G. Needham, Cornell University. Transatlantic Telephony by Dr. Frank B. Jewett, Vice-President of the American Telephone and Telegraph Company.

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BOOKS RECEIVED.

Light by Vivian T. Saunders, M. A., Assistant Master at Uppingham School. Cloth. Pages vii+320. 18.5x12 cm. 1927. London, John Murray, Albermarle Street, W.

General Chemistry, a Cultural Course Based upon the texts of the late Alexander Smith by James Kendall, F. R. S., Professor of Chemistry and Administrative Chairman of the Department of Chemistry, Washington Square College, New York University. Cloth. Pages xxix+676. 20x13 cm. 1927. The Century Co., 353 Fourth Avenue, New York. Price $3.50

Practical Chemistry, Fundamental Facts and Applications to Modern Life by Newton Henry Black, Assistant Professor of Education, Harvard University and James Bryant Conant, Associate Professor of Chemistry, Howard University. Revised Edition. Cloth. Pages x+522. 12.5x19 cm. 1927. The Macmillan Company, New York.

An Experiment with Time by J. W. Dunne. Cloth. 208 pages. 22x14 cm. 1927. The Macmillan Company, New York. Price $2.50.

The History and Significance of Certain Standard Problems in Algebra by Vera Sanford. Cloth. Pages vii+102. 23x15 cm. 1927. Bureau of Publications, Teachers College, Columbia University, New York City.

Modern Experimental Chemistry by Herbert R. Smith, M. A., Lake View High School, Chicago and Harry M. Mess, B. A., Nicholas Senn High School, Chicago. Paper. xviii+204. 25x19 cm. 1927. Henry Holt and Company, New York.

On Being a Girl by Jessie E. Gibson, Dean, North Central High School, Spokane, Washington, with an Introduction by Henry Suzzallo, Ph. D. Cloth. Pages xiv+326. 19x12 cm. 1927. The Macmillan Company, N. Y.

Laboratory Exercises for a Brief Course in Chemistry by Lyman C. Newell, Professor of Chemistry, Boston University, Boston, Mass. Cloth. Pages xii+152. 20.5x13.5 cm. 1927. D. C. Heath and Company, 239 West 39th Street, New York. Price $1.00. Packet extra sheets 36 cents. Bound in cloth (not interleaved) 88 cents.

Foundations of Biology by Lorande Loss Woodruff, Professor of Biology in Yale University. Third Edition. Cloth. xxiii+546. 19.5x12.5 cm. 1927. The Macmillan Company, New York.

Manual of Biological Forms by George A. Baitsell, Associate Professor of Biology in Yale University. Revised Edition. Cloth. Pages xiv+411. 19.5x12.5 cm. 1927. The Macmillan Company, New York.

Analytic Geometry by Clyde E. Love, Ph. D., Professor of Mathematics in the University of Michigan. Revised Edition. Cloth. Pages xiv+257. 19.5x12.5 cm. 1927. The Macmillan Company, New York.

General Physics by Henry Crew, Ph. D., Fayerweather Professor of Physics in Northwestern University. Fourth Edition. Cloth. Pages xi+674. 21.5x14 cm. 1927. The Macmillan Company, New York.

The Teaching of Junior High School Mathematics by David Eugene Smith and William David Reeve, Professors in Teachers College, Columbia University. Cloth. Pages viii+411. 21x14 cm. 1927. Ginn & Co. Catalogue price $2.00, subject to usual discount.

Buckingham-Osburn Searchlight Arithmetics, Book Three by B. R. Buckingham, Director of the Bureau of Educational Research, Ohio State University and W. J. Osburn, Director of Educational Measurements, State Department of Public Instruction, Madison, Wisconsin. Cloth. Pages xii+491. 19x13.5. 1927. Ginn & Co. Price 96 cents.

The Fundamentals of Astronomy by S. A. Mitchell, Ph. D., LL. D., Professor of Astronomy of the University of Virginia and Director of the Leander McCormick Observatory and C. G. Abbott, M. S., D. Sc., Assistant Secretary of the Smithsonian Institution and Director of the Astrophysical Observatory. Cloth. Pages xi+307. 21.5x13.5 cm. 1927 D. Van Nostrand Company, Inc., New York. Price $3.00.

Problems in Classroom Method, A Manual of Case Analysis for High School Supervisors and Teachers in Service by Douglas Waples, Ph. D., Assistant Professor of Education, The University of Chicago. Cloth. Pages xxii+609. 19.5x12.5 cm. 1927. The Macmillan Company, New York.

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Secondary School Curricula by Willis L. Uhl, Professor of Education, University of Wisconsin. Cloth. Pages xx+582. 19.5x13 cm. 1927. The Macmillan Company, New York.

Healthful Living, Based on the Essentials of Physiology for High School Pupils. Revised Edition by Jesse Feiring Williams, A. B., M. D., Professor of Physical Education, Teachers College, Columbia University. Cloth. Pages ix+596. 19.5x13 cm. 1927. The Macmillan Company, New York.

Algebra To the Quadratic, A Book for Beginners by R. W. M. Gibbs, B. A. (Camb.), B. Sc. (Lond.). Cloth. Pages 160. 18.5x12 cm. 1927. Oxford University Press, American Branch, New York. Price $1.00.

Advanced Constructive Geometry by J. F. Dowsett, Lecturer and Chief Instructor in Geometry and Graphics, London County Council School of Building, Brixton. Cloth. Pages viii+340. 22x13 cm. 1927. Oxford University Press, American Branch, New York. Price $9.00.

Four-Figure Tables by the late C. Godfrey, M. V. O., M. A., and A. W. Siddons, M. A., Late Fellow of Jesus College, Cambridge Assistant Master at Harrow School. Cloth. Pages 40. 22x15 cm. 1927. Cambridge University Press, London. American Agents, Macmillan Company.

The Foundations of Euclidean Geometry by Henry George Forder, B. A., Sometime Scholar of Sidney Sussex College, Cambridge. Cloth. Pages xii+349. 21.5x13.5 cm. 1927. Cambridge at the University Press, London. Sole American Agents, The Macmillan Company.

Statistical Mechanics with Applications to Physics and Chemistry by Richard C. Tolman, Ph. D., Professor of Physical Chemistry and Mathematical Physics, California Institute of Technology. Cloth. Pages 334. 23x15 cm. 1927. The Chemical Catalog Company, Inc., 419 Fourth Avenue, at 29th Street, New York, U. S. A. Price $7.00.

Hygiene and Sanitation by Jesse Feiring Williams, M. D., Professor of Physical Education, Teachers College, Columbia University. Cloth. 334 pages. 19.5x13 cm. 1927. W. B. Saunders Company, West Washington Square, Philadelphia.

Machine Shop Practice by Harry A. Jones, Machine Shop Instructor, Technical School, Vancouver, B. C. Cloth. Pages v+172. 23x15 cm. 1926. Thomas Nelson & Sons, Limited, New York.

An Outline of Physics by A. C. Palmer, M. S., Pomfret School. Paper. Pages iv+30. 19x13.5 cm. 1927. The University Supply and Book Co., 10109 Wilbur Avenue, S. E., Cleveland, Ohio. 50 cents per copy.

Physics Problems and Questions by Franklin T. Jones, Fourth Edition Paper. Pages vi+90. 19.5x13.5 cm. 1927. The University Supply and Book Company, 10109 Wilbur Avenue, Cleveland, Ohio. 50 cents per copy.

The General Theory of Thermodynamics by J. E. Trevor, Ph. D., Professor of Thermodynamics in Cornell University. Cloth. Pages x+104. 20.5x13.5 cm. 1927. Ginn and Company, 15 Ashburton Place, Boston. Price $1.60.

Chemical Calculations by Ernest L. Dinsmore, A. B., Chairman of the Chemistry Department, Boys High School, Brooklyn, New York. Cloth. Pages vi+182. 19x12.5 cm. 1927. Globe Book Company, New York.

Standard Service Arithmetics, Grade Three by F. B. Knight, College of Education, University of Iowa, J. W. Studebaker, Superintendent of Schools, Des Moines, Iowa, G. M. Ruch, College of Education, University of California. Cloth. Pages xiii+391. 18.5x12.5 cm. 1926. Scott, Foresman and Company, New York.

The Logic of Modern Physics by P. W. Bridgman, Hollis Professor of Mathematics and Natural History in Harvard University. Cloth. Pages xiv+228. 21.5x14.5 cm. 1927. The Macmillan Company, New York. Price $2.50.

A Compend of Human Physiology, sixteenth edition, especially adapted for the use of Medical Students by Albert P. Brubaker, A. M., M. D., Professor of Physiology and Medical Jurisprudence in the Jefferson Medical College. Cloth. Pages viii+281. 17.5x11.5 cm. 1927. P. Blakiston's Son & Company, 1012 Walnut Street, Philadelphia. Price $2.00.

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IN RESPONSE to the urgent demand, Part I of the Report of the National Committee on Mathematical Requirements, which contains all of the recommendations of the Committee, is now published under the title *The Reorganization of Mathematics in Secondary Education.* This volume is edited by Dr. J. W. Young, Chairman of the Committee under whose direction the Report was originally published.

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Biology, with 338 Illustrations by William H. Atwood, Director of the Department of Biology, Milwaukee State Normal School. Cloth. Pages xi+522. 19.5x13 cm. 1927. P. Blakiston's Son & Company, 1012 Walnut Street, Philadelphia. Price $1.68.

Freshman Mathematics by George Walker Mullins, Associate Professor of Mathematics, Barnard College, Columbia University and David Eugene Smith, Professor Emeritus of Mathematics, Teachers College, Columbia University. Cloth. Pages vi+386. 20.5x14 cm. 1927. Ginn and Company, 15 Ashburton Place, Boston. Price $3.00.

The Quality of the Educational Process in the United States and in Europe by William S. Learned. Bulletin Number twenty. Paper. Pages x+133. 25.5x19 cm. 1927. New York, The Carnegie Foundation for the Advancement of Teaching, 522 Fifth Avenue.

The Harvard Tests High School Chemistry, Form A and Form B by Henry L. Gerry, The Teachers College of the City of Boston. Paper. 23.5x19 cm. 1927. Ginn and Company, 15 Ashburton Place, Boston. Price per pad 48 cents.

The New Algebra by H. E. Slaught, Ph. D., Sc. D., Professor of Mathematics in the University of Chicago and N. J. Lennes, Ph. D., Professor of Mathematics in the University of Montana. Pages vii+302. 14x19.5 cm. 1926. Allyn and Bacon.

Geology and Mineral Resources of the Dixon Quadrangle by Russell Stafford Knappen, Bulletin Number 49. Paper. 141 pages. 25x17 cm. 1926. Urbana, Illinois.

The Buckingham-Osburn Searchlight Arithmetics, Book Two by B. R. Buckingham, Director of the Bureau of Educational Research, Ohio State University and W. J. Osburn, Director of Educational Measurements, State Department of Public Instruction, Madison, Wisconsin. Cloth. Pages viii+349. 19x13 cm. 1927. Ginn and Company. Price 76 cents.

A Handbook of Private Schools for American Boys and Girls. An annual survey. Eleventh Edition. Cloth. 1186 pages. 18x12 cm. 1926-1927. Porter Sargent, 11 Beacon Street, Boston, Massachusetts.

The Carnegie Foundation for the Advancement of Teaching, Twenty-first annual report of the President and of the Treasurer. Paper. 250 pages. 25.5x18.5 cm. 1926. 522 Fifth Avenue, New York City.

Mathematical Statistics by Henry Lewis Rietz, Professor of Mathematics, The University of Iowa. Pages xi+181. 13x19 cm. Open Court Publishing Company. Price $2.00.

A Debate on the Theory of Relativity by R. D. Carmichael, Professor of Mathematics, University of Illinois, H. T. Davis, Assistant Professor of Mathematics, Indiana University, W. D. MacMillan, Professor of Astronomy, University of Chicago and M. E. Hufford, Assistant Professor of Physics, Indiana University with an introduction by William Lowe Bryan, President of Indiana University. Pages viii+154. 13x19.5 cm. $2.00. Open Court Publishing Company.

The National Council of Teachers of Mathematics, The Second Yearbook. Paper. Pages xiii+297. 23x15 cm. 1927. Paper $1.25, cloth $1.50. Bureau of Publications, Teachers College, Columbia University, New York City.

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Plane Analytical Geometry by I. A. Barnett, University of Cincinnati. Cloth. Pages v+269. 20.5x13.5 cm. 1926. John Wiley & Sons, Inc. Price $3.00.

Among the many good textbooks in mathematics that have reached us in the past few months few deserve more of the attention of college teachers and students than Dr. I. A. Barnett's Plane Analytical Geometry for college freshmen. One of the important features is the use of an algebra-geometry dictionary which keeps the basic idea of the subject before the student and makes evident at every step the parallelism of geometry and algebra in the solution of problems. Many clear diagrams supplement the theoretical discussions and the application of each new principle is made clear by one or more illustrative examples completely solved. An abundance of well-constructed exercises follow in each case. This book deserves and will undoubtedly receive a hearty welcome by teachers and students of analytics. G. W. W.

Tests and Measurements in High School Instruction by G. M. Ruch, Professor of Education, University of California and George D. Stoddard, Assistant Professor of Psychology and Education, State University of Iowa. Cloth. Pages xix+381. 19.5x13 cm. 1927. World Book Company, Yonkers-on-Hudson, New York. Price $2.20.

Secondary school teachers, supervisors and administrators are here presented with a handbook on the tests available for high school work and on the selection and preparation of such tests. It is arranged in four major parts as follows: Part One gives the status, uses, limitations, and selection of tests. The authors classify and discuss the evident advantages of standard tests for supervision and instruction but also recognize their limitations. Part Two presents a full description of available tests in high school subjects. These are classified by subjects and directions are given for administering and scoring each test as well as a statement of what it measures. The bibliographies which follow each subject give complete information regarding the literature on the subject. Part Three aims to show how to make use of the new type tests so that they will yield better results than the essay-type examinations. Part Four discusses the fundamental principles underlying the construction of objective tests. This section will be of particular value to teachers who wish to design new tests, and to instructors and students of educational measurements in the normal colleges and the universities.

G. W. W.

Biology, by William H. Atwood, Director of the Department of Biology, Milwaukee State Normal School. xi + 522 pp., 338 illustrations. P. Blakiston's Son and Company, 1012 Walnut St., Philadelphia. 1927.

The organization used in this new text is on the basis of units. The ten main ideas around which the units are built are: How plants and animals live; The food relations of plants, animals and man; How living things grow and reproduce; The control of the activities of living things; The biology of health and disease; The problems of economic biology; The importance of life and The conservation of biologic wealth. Besides, ten pages are devoted to a brief history of biology.

The working out of each unit consists in the treatment of a number of definite problems. The presentation of the subject matter is pedagogical. Suggestions to pupil and teacher in the form of questions, activities, field trips, projects, reports and lists of references are scattered throughout the text and there is a glossary at the back of the book.

The author expresses the opinion that the greatest good and interest in biology teaching comes from gaining an understanding of the intimate relationship of plants and animals to man. This relationship can not be shown effectively and interestingly if a consideration of man is deferred to the end of the course. Activities and functions for plants, animals and mankind are treated in a united study. The text is suitable for use in the tenth year or later in the high school course. It is an excellent text built along modern lines. Jerome Isenbarger.

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Chemical Calculations, by Ernest L. Dinsmore, A. B. Chrirman of the Chemistry Department, Boys High School, Brooklyn, N. Y. Cloth. Pages vi+182. 19x13 cm. 1927. Globe Book Co., N. Y.

This is stochiometry brought down to date. We are introduced to the modern view of subatomic structure in the first chapter (which deals with "Matter and Changes" and which is illustrated with a chart of the first 25 elements arranged according to their atomic numbers and pictured as to their supposed sub atomic structure. While we have no calculations in this introductory chapter the second chapter begins to furnish plenty of them (dealing with the gas laws) and most of the rest of the book is given over to teaching and giving examples of the usual type of problems in chemical calculation. Two chapters at the end of the book give "Problems from Recent Examinations." While not encroaching on the province of the text book unduly the author takes occasion from time to time to teach briefly some of the essentials of the chemistry giving rise to the problems. This is notably true in the chapter dealing with solutions. This book should be especially useful to teachers who are preparing pupils for college entrance examinations. F. B. W.

The Seven Seals of Science, by Joseph Mayer, Ph. D., Head of the Department of Economics and Sociology in Tufts College. Cloth. Pages xiv+444. 21x14x3.5 cm. 1927. The Century Co., N. Y.

This book is different! Here we have a student of social science giving us a splendid historical setting to our seven sciences, Mathematics, Astronomy, Physics, Chemistry, Biology, Geology and Psychology. Note the chronological order of these sciences. The author takes us back and comes down the ages with us showing us how and when each of the sciences had its beginnings. He keeps us always posted as to the political developments that were going on simultaneously with the growth of the sciences. One who was just a scientist could not have written this book. It is a marvel that one who makes of science only an avocation could have treated the purely scientific part with as masterly a hand and with so little of error. The correlation of the sciences is splendid. Many a fine physicist or chemist or mathematician needs this book to show him what the other fellow has been doing. Many a teacher of a special science can learn of this book how to teach his own science more effectively. That the spirit of the book is thoroughly scientific can be seen from the following quotation, taken from the last paragraph of the final chapter (on Social Science in the Making) "It behooves us to steer a middle course between these extremes, neither failing to keep our feet firm upon the ground of indisputable fact nor fearing to raise our heads aloft into the free air of speculative hypothesis. "Every educated man should read this book. Teachers need it even more than others and science teachers cannot afford to miss it. F. B. W.

Digest of Elementary Chemistry, by Martin Mendel, M. A. Thomas Jefferson High School, Brooklyn, N. Y. Paper. Pages v+234.18x13 cm. 1927. Globe Book Co., N. Y.

As the name implies this hand book is a sort of condensed compendium of the essentials of a year of secondary school chemistry. It is almost telegraphic in its brevity of treatment but "hits the high spots."

It contains plenty of material to satisfy the requirements of the College Entrance Board and it would seem to be excellently suited to the need of those pupils who must prepare for the Board Examinations. The Electron Theory is explained and is applied throughout the book. There are many exercises at the ends of the chapters, many of the questions having been taken from recent examinations. There is a brief synopsis of the elements of beginning organic chemistry in one of the later chapters and this is followed by a chapter on simple qualitiative tests for both radicals and metals.

A chapter of definitions, various tables and a liberal supply of sample examinations complete the book. Teachers who have students who expect to have to take College Board Examinations should send for this book. F. B. W.

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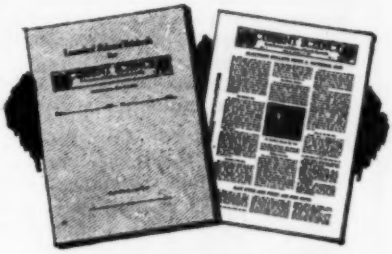

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Our Wild Animals, by Edwin Lincoln Moseley, Head of the Science Department, State Normal College, Bowling Green, Ohio. Cloth. Pages 310. 13x19 cm. 1927. D. Appleton & Co., New York.

This is one of the most fascinating and interesting books that the reviewer has read for years. Although it is written for pupils of the fifth and sixth grade it is just as well adapted for adults. There are 30 chapters, each describing an animal, or an animal family, found in the United States. Each animal described is illustrated by an excellent photograph. To encourage class discussion thought provoking questions are placed in each chapter.

A four page bibliography of books that can be found in most Public Libraries is a valuable feature of the book. C. M. T.

Everyday Electricity, by Joseph R. Lunt, Head of the Science Department, Teachers College, Boston, Mass. Cloth. Pages 297. 13x19 cm. 1927. The Macmillan Co., New York.

Everyday Electricity is a simple experimental study of electricity written for boys of High School age. There are 233 illustrations many of them being simple diagrams that a boy of 9 or 10 can easily understand. 46 pages are given to first principles of Radio.

The best criticism I can give for this book is the fact that when my little boy of nine and one half years of age looked into it he wanted it for his own to keep so he could work the experiments and learn about electricity for himself. C. M. T.

Teaching: Profession and Practice, by A. R. Brubacher, Ph. D., President State College for Teachers, Albany, New York. Cloth. Pages xvii+301. 20x13 cm. 1927. The Century Co., New York. Price $2.00.

Here is a book which should be read by every young man and woman who is preparing for teaching. It presents a view of teaching as a profession, and will help young or apologetic teachers to make a proper estimate of the importance and dignity of their work.

After a clear analysis of the meaning of the term profession the author shows that teaching has all the necessary and sufficient characteristics of a profession. He next discusses adequate preparation and training for teaching and the principal impediments in the way of progress such as immaturity of teachers, low standards of preparation, low salaries especially for the mature teacher, mobility of teachers and too few men teachers. The chapter on professional organizations is especially commendable for the sane statement of the advantages of such organizations and the methods they should adopt for promoting the profession. Another valuable section is the discussion of the ethics of the profession and the proposed code of ethics for teachers. A wide circulation of this book will do much to promote the teaching profession. G. W. W.

Basic Material for a Pharmaceutical Curriculum prepared under the Direction of W. W. Charters, University of Pittsburgh, A. B. Lemon, University of Buffalo, Leon M. Monell, University of Buffalo. Cloth. Pages xiii+366. 23x14.5 cm. 1927. McGraw-Hill Book Company, Inc., New York, 370 Seventh Avenue. Price $4.00.

This is a report prepared by the authors from a study carried on by a technical staff working for a period of about two-and-a-half years. It is a great example of making the proper preparation for scientific curriculum building. The first step in the study was to analyze the life of the practising pharmacist, the proprietor of the neighborhood drug store in the city or the small town druggist, in order to discover his duties and activities. The investigation included a study of the social and community activities of the pharmacist as well as of his professional or trade activities.

The body of the report consists of a very complete set of tables and lists of terms, problems, etc., arranged under the various branches of study to be included in the curriculum. It is the raw material from which the courses are to be constructed. Reading thru these lists one is impressed with the thorough and complete work of the staff in determining the content and relative importance of the factors that should be included in the pharmaceutical curriculum. G. W. W.

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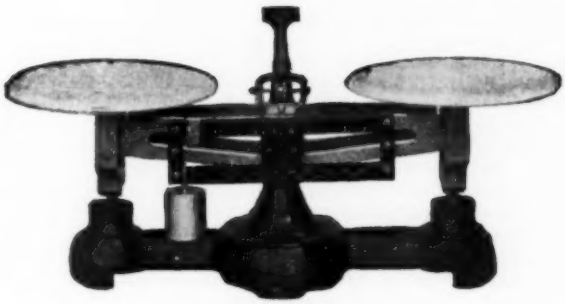

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Elements of Chemistry, by Harry N. Holmes, Professor of Chemistry, Oberlin College and Louis W. Mattern, Head Teacher of Chemistry, McKinley Technical High School, Washington, D. C. Cloth. Pages x+519. 20x14 cm. 1927 (April) Macmillan.

Somewhere in the Good Book there is a reference to "the making of many books." In the field of elementary chemistry there seems to be "no end" to the output of text books. Yet we have in these two authors two teachers whose experience should by all means be preserved in form for use by those who cannot be so fortunate as to sit under their instruction and inspiration. This text attempts to arouse that interest which the authors (in their preface) say "is the salt that makes a student knowledge thirsty." The book is written avowedly with the intention of "first capturing" interest and attention and then leading the class on to scientific thinking."

In glancing over the text we note few radical changes in the order of treatment over that which is usual. Some elementary organic chemistry is taught rather earlier than is usual. Valence is introduced a bit sooner than in many texts, which is eminently proper (although the electronic explanation is left until the latter part of the book is reached). As one would expect because of the keen interest of one of the authors in colloid chemistry there is a very competent chapter on that subject. The book is well illustrated which is a great help in catching interest on the part of the student. Perhaps the outstanding characteristic of the text is its style which is admirably calculated to arouse and retain the interest of the pupil. High School teachers of chemistry will, of course, want to see this recent addition to the list of secondary chemistry texts. F. B. W.

Modern Experimental Chemistry, by Herbert R. Smith, M. A. Lake View High School, Chicago and Harry M. Mess, B. A. Nicholas Senn High School, Chicago. 1st edition, pages xviii+204. 19x25 cm. Frontispiece and numerous figures. Paper covers. 1927. Henry Holt & Co., N. Y.

A modern loose leaf manual containing 85 experiments and much instruction about laboratory work. The well known authors believe that the experimental part of high school chemistry is the more essential part and that it should precede the text book work. The experiments are organized into groups that are larger than the usual content of experiments in high school manuals and they are presented somewhat in the form of projects. One good feature of the manual is that it supplies more work with each experiment than can be expected of all the pupils thus giving the exceptional student something to keep him active throughout the whole time of the exercise. The essentual part of the work is clearly indicated by a mark in the margin of the page. All pupils are expected to accomplish this minimum amount.

The table of contents outlines a minimum course of fundamentals but many more experiments are provided. A manual for teachers may be obtained from the publishers by request. This should be valuable to teachers with but little experience. A companion book, an outline of Fundamentals of Modern Chemistry has been prepared by the same authors. All high school teachers of chemistry will profit by seeing this new laboratory manual. F. B. W.

The Harvard Tests, High School Chemistry, Forms A and B prepared by Henry L. Gerry, The Teachers College of the City of Boston. 1927. Ginn & Co.

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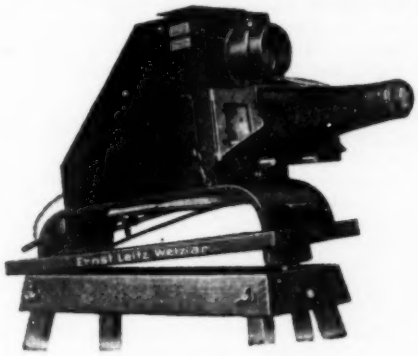

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Modern Plane Geometry, by John R. Clark, The Lincoln School, Teachers College, Columbia University; and Arthur S. Otis, Author of Statistical Method in Educational Measurement and Otis Self Administering Tests of Mental Ability. Pages x+310. 14.5x19.5 cm. 1927. Yonkers-on-Hudson: World Book Co. $1.36.

The authors of Modern Plane Geometry believe that geometry is taught for the purpose of developing in the student "the power to analyze, discover, and prove geometric facts in the way best calculated to create effective habits of thinking." To this end the authors have produced a book with the following special features:

1. An introductory course in which the student is made familiar with straight line, arcs, angles, superposition, and the rest, by concrete experiences with these objects. During this course he learns the basic constructions, does actual superposing, and learns the purpose and nature of a demonstration.

2. The development before the statement of a proposition. It provides for the discovery of the fact by the student before he sees the statement of the proposition in the book.

3. The question exercise. The "original" exercises are put in the form of questions. Thus, what kind of a quadrilateral is enclosed by the bisectors of the angles of a parallelogram? The student is required to investigate, reach a conclusion, and prove it. Again, does the bisector of any angle of an isosceles triangle bisect the opposite side? The student investigates, finds the answer is "no," and proceeds to prove his conclusion.

4. The challenge. The student is often challenged to discover a new truth. Thus, after he has discovered that two triangles are congruent if two sides and the included angle, etc., and if two angles and the included side, etc., and has learned how to make exact copies in two ways, he is asked the question: Can you think of a third way to make an exact copy of a triangle?

5. Student self classification. Provision is made for three levels of attainment: and the same exercises serve for these three levels.

6. Provision for testing the pupils' mastery. (1) A group of "Written Exercises" is provided at the end of each book. (2) Seven new-type objective test are provided for testing the students' power to think geometrically.

The book furnishes 1600 exercises. Many of these are practical applications. Much emphasis is placed on the analytic method.

The book justifies the title "Modern Plane Geometry" and deserves the careful examination of every teacher of geometry.

J. M. Kinney.

An Experiment with Time by J. W. Dunne. Cloth. 208 pages. 22x14 cm. 1927. The Macmillan Company, New York. Price $2.50.

At a time when there is so much popular interest in spirit messages, telepathy, four dimensional space, and excursions forward and backward in time, a book describing a series of scientific experiments designed to explain the cause of a dream visualizing an event that takes place on the following day gives promise of being a "best seller." A series of such remarkable dreams stimulated the investigation. The first part of the book relates the dreams and describes the events which followed. An experiment was then devised and carried out to see if there is some hidden peculiarity in the nature of time that will explain this ability to experience portions of time displaced from their normal positions. This experiment is clearly described and can be verified by any one. But at this point the layman must close the book or do some intensive study. In order to proceed further the reader will have to possess considerable scientific background and be acquainted with the logic of modern science. The latter part of the book proposes an explanation of the facts observed. Many will probably say the explanation does not explain, but no one will deny that it stimulates thought.

G. W. W.

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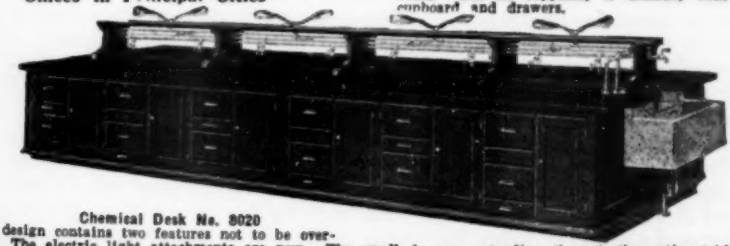

Chemical Desk No. 8020
This design contains two features not to be overlooked. The electric light attachments are new. The small drawers extending through the entire table provide storage room for long condensing tubes and other equipment. This desk will accommodate twenty-four students working in groups of eight.

Plane Trigonometry, by Herbert E. Buchanan, Ph. D. and Pauline Sperry Ph. D. Pages vi+112. 16x24 cm. 1926. Richmond: Johnson Publishing Co.

This book is brief and conservatively progressive. Other features which should be mentioned are the following:

1. By the early introduction of the definitions of the trigonometric functions of the general angle unnecessary duplication of material is avoided.
2. The theory of projection is used in making the proofs of the addition theorems.
3. The periodicity properties are discussed in both the rectangular and the polar coordinates.
4. The general appearance of the book is pleasing.

J. M. Kinney.

An Outline of Physics by A. C. Palmer, and *Physics—Problems and Questions, Fourth Edition by Franklin T. Jones* are two very valuable booklets for physics teachers and students. The outline contains the essentials of the high school scource systematically arranged and stated in clear, concise language. Each principle is followed by one or two references to problems which illustrate it. The Physics-Problems and Questions need no introduction. In addition to the problems in previous editions the fourth edition contains many new questions illustrating the recent developments and applications, making a total of one thousand problems and questions. These two pamphlets will be valuable aids to the slow student who has difficulty in organizing his reviews and especially to the student preparing for college entrance and other competitive examinations. These pamphlets may be obtained from The University Supply and Book Co., 10109 Wilbur Avenue, Cleveland, Ohio, at fifty cents per copy with the customary discounts for teachers or in quantity. G. W. W.

WESTWARD THE COURSE OF INDUSTRY TAKES ITS WAY.

In January, 1908, the center of industry in the United States was on the northern boundary of Indiana, about 110 miles east of Chicago. In January, 1918, it was still on the northern boundary of Indiana but had moved about 50 miles nearer to Chicago. In January, 1926, it had moved 25 miles to the southwest of its position in 1918 and was about 50 miles southeast of Chicago. The total movement in the 18 years from 1908 to 1926 was about 75 miles in a west by south direction. This slow movement of the center of industry during a period when the capacity of prime movers in central stations and manufacturing plants increased about 140 per cent indicates that industrial development in the United States is proceeding at about the same rate in all sections but a trifle more rapidly in the western and southern parts of the country.

These determinations of the center of industry, which have been made by the Geological Survey, Department of the Interior, are based on the capacity of steam engines, steam turbines, water wheels, and internal-combustion engines installed in manufacturing plants and in public-utility power plants. Twice the weight is given to the power equipment in public-utility power plants, as it is used twice as much as power equipment in manufacturing plants. Previous determinations of the center of industry have been based on the installed capacity of prime movers in manufacturing plants only. It is believed that more representative results are obtained by using the capacity of power equipment in both manufacturing and public-utility plants.

The geographic center of the United States is near the center of the northern boundary of Kansas, and the center of population is in Owen County, southwestern Indiana. The center of industry of the United States in 1926 was therefore 640 miles east by north of the geographic center and about 170 miles due north of the center of population.—Department of Interior.

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ANNUAL MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

AT CASS TECHNICAL HIGH SCHOOL, DETROIT, MICHIGAN, NOVEMBER, 25, 26, 1927.

GENERAL MEETINGS.

Preliminary Announcement—The full program will be given in the next number of School Science and Mathematics.

Nationally known speakers have been secured for the general meetings. Professor Charles H. Judd, the University of Chicago, will lecture on Some Recent Experimental Studies which Throw Light on the Nature of Mathematical Thinking.

Professor Wm. H. Hobbs will deliver an illustrated lecture on the Results of his Summer Expedition to Greenland.

Other speakers will be announced later.

There will be several lectures by representatives of the industries in Detroit.

Professor Elliott R. Downing, University of Chicago, will deliver a lecture following the Friday evening dinner.

SECTION MEETINGS.

Biology Section. J. R. Locke, chairman, has secured speakers to discuss the following topics: 1. Development of Serums and Vaccines. 2. Some Phases of Development of the Rubber Industry. 3. Some Phases of Genetics.

Chemistry Section. Raymond W. Osborne, chairman, has promised lectures on the following: 1. The Manufacture of Drugs. 2. Some Aims in Elementary Chemistry. 3. Helps in Teaching Industrial Chemistry. 4. Certain Aspects of Learning in Chemistry. 5. Efficient Demonstration Work in Teaching Chemistry. 6. The Cooperative Method of Handling the Overload.

General Science Section. Francis D. Curtis, chairman, has formulated the following program for his meeting: 1. An Investigation of New Curricular Units in General Science. 2. Superstition in the Teaching of Science. 3. Goals for Accomplishment in General Science. 4. Supervised Study in Science. 5. The Contract Method of Teaching Science.

Geography Section. Viva Dutton Martin, chairman, has been able to secure Prof. Hobbs for her section. He will lecture on Cruises Along By-Ways of the Pacific. Other subjects to be discussed are: Creating Interest in the Commercial Geography Class. 2. An Opportunity for Student Activity in Commercial Geography. 3. The Value of the Bulletin Board in Teaching Commercial Geography. 4. A Project in Commercial Geography.

Mathematics Section. Joseph A. Nyberg, chairman, has formulated the following program: 1. Functional Analysis of a Unit in Ninth-Grade Mathematics. 2. Adjusting the Course of Study to the Ability of the Pupil. 3. An Investigation of Achievement in Plane Geometry.

Physics Section. M. J. M. Phillips, chairman, promises papers on the following topics: 1. Some Experiment in High School Physics. 2. Five years of Experimenting with Objective Tests in Physics. 3. Physical Research in the Automotive Industry.

In connection with the meetings there will be exhibits and excursions to some of Detroit's most interesting industries.